INCORPORATING ACCESSIBILITY INTO ENVIRONMENTAL JUSTICE ASSESSMENT: APPLICATIONS IN THE ATLANTA METROPOLITAN REGION

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INCORPORATING ACCESSIBILITY INTO ENVIRONMENTAL JUSTICE ASSESSMENT: APPLICATIONS IN THE ATLANTA METROPOLITAN REGION

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SUMMARY

Local agencies must comply with environmental justice regulation and as such, it is important that they possess practical tools to identify target populations and assess impacts of projects, programs, and policies on these populations. There is a plethora of methods that can be used to achieve both ends and they vary among agencies.

The focus of environmental justice assessments is often at a project level. The micro-level analysis of environmental justice inhibits the evaluation of impacts from policies (and projects also) on a regional level. Accessibility is a regional impact of transportation improvements that cannot be evaluated at a project level. It is becoming increasingly common practice that Metropolitan Planning Organizations (MPO) assess the accessibility of their region, but few incorporate this benefit into the environmental justice evaluation. This is a benefit that has implications for participation in society and the lack of accessibility inevitably becomes a burden.

Through a review of literature on environmental justice, its history and its implementation, one understands two major components of environmental justice are ensuring procedural equity and outcome equity in transportation improvements. Although ensuring procedural equity through public involvement is consistently incorporated into MPO transportation planning, approaches to quantitatively assess outcome equity vary widely. A basic framework can be adapted to complete quantitative analysis of environmental justice outcomes. This framework includes: identifying the target population and study area, determining the impacts, and analyzing disproportionality. There are a variety of methods to achieve each of these ends. The study area can be

delineated using polygon, centroid, or within analysis or through a mathematic transformation. Determining the impacts depends on the impact that is to be evaluated. Disproportionality can be determined through a buffer comparison index or an area comparison index.

The impact evaluated in this analysis is accessibility. There is a plethora of approaches to measuring accessibility. Conventional methods including cumulative opportunity and gravity models can be employed. There is also the option for more advanced methods such as space-time measure and those using the random utility theory. In all, these measures fall into a framework where the components of transportation, land use, individual preference and temporal constraints, are addressed at various levels by taking either a spatial or category approach. The spatial approach addresses infrastructure and locations of destinations and the category approach addresses the person and the utility of the destination.

As mentioned previously, accessibility is becoming a concern for an increasing number of MPOs in their planning process and some MPOs across the country are accounting for accessibility in their environmental justice analyses. Boston Region Metropolitan Planning Organization, Mid-Ohio Regional Planning Commission, National Capital Regional Transportation Planning Board, Southern California Association of Governments, and Puget Sound Regional Council incorporate accessibility in quantitative analyses for environmental justice. Based on a review of these MPOs, the literature and the Atlanta Regional Commission’s environmental justice compliance procedures and process for analyzing accessibility, an approach was developed to assess accessibility to key facilities for various populations and applied to the Atlanta Metropolitan region.

This approach used the basic environmental justice quantitative analysis framework (identifying the target population and study area, determining the impacts, and analyzing disproportionality) and created spatial statistical clusters of target populations to identify the study area and population, measured accessibility using cumulative opportunity to determine the impacts and analyzed disproportionality using a modified buffer comparison index. The results provide an understanding of the location of K-12, technical, and higher educational opportunities as well as libraries and parks and how these locations are related to areas with high concentrations of target populations.

The main contribution of this work is that is provides and demonstrates a general, regional scale method to evaluate accessibility to economic and social opportunities and services. Translating this work into a more general context, the tools can be used to identify environmental justice target populations with a regional scope to minimize complications with disproportionality thresholds. This method also identifies areas with high concentrations of target populations, pinpointing areas of overrepresentation of target populations and estimating the distribution of these populations across the region, which can provide more practical and useful information than a tract-by-tract demographic profile.

Accessibility to destinations is a benefit of the transportation system and when these destinations are also opportunities for social inclusion, accessibility becomes a liberty that should be extended to all segments of the population. Disparate accessibility is significant because it can be viewed as an inequitable cumulative outcome of transportation investments and therefore becomes an environmental justice concern. Alternative approaches for environmental justice assessments of regional outcomes such as accessibility provide opportunities for MPOs to gain a greater understanding of the regional impacts of transportation improvements as well as more accurately comply with the spirit of environmental justice regulations. The approach was applied to conduct an analysis of racial and ethnic minority access to educational and recreational facilities, demonstrating inequitable access to parks in the Atlanta Metro region. As a result, a more comprehensive idea of accessibility for environmental justice populations was obtained.

CHAPTER 1

LITERATURE REVIEW

Environmental Justice History and Legislation

The environmental justice movement emerged in 1982 in North Carolina. A protest led by a small, predominately African-American community in Warren County, NC resulted in a federal investigation of the location of toxic waste landfills in the southeast region. The consequent study conducted by the United States General Accounting Office revealed that a disproportionately high number of hazardous waste facilities were sited in or near low-income and minority neighborhoods throughout the Southeast. Subsequent studies found supporting results (Owens 2008). In 1994, President Clinton signed Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, which explicitly states that all federally funded programs must develop policies and programs to achieve environmental justice. This executive order mandated the development of environmental justice regulation in all federal agencies. These principles are applicable for all phases of project development for any agency receiving federal funds, whether the improvement is federally funded or not.

Environmental justice is “the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income” in relation to the development, implementation, and enforcement of regulations and policies (EPA Website). The environmental justice Executive Order effectively bridges two previous regulations: Title VI of the 1964 Civil Rights Act, which focuses on nondiscrimination, and the National Environmental Policy Act (NEPA), which focuses on protecting the natural environment. NEPA also has social and human requirements and the memorandum sent to departments and agencies accompanying the Executive Order specifically noted how NEPA requirements applied to environmental justice, especially though the community input process (Council on Environmental Quality 1997). The Civil Rights Act and NEPA established the basis for environmental justice and give authority to the Executive Order.

After the Order was signed, the transportation community outlined specific goals and regulations in the Department of Transportation (DOT) Order 5610.2 in 1997. The Federal Highway Administration (FHWA) issued DOT Order 6640.23 in 1998, and the FHWA and Federal Transit Administration (FTA) issued a memo in 1999, each of which provided more specific details for regulating and monitoring transportation activities. The catalog of guidance results in the FHWA and the FTA defining environmental justice as having three fundamental principles (FHWA Website):

1) To avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations.

2) To ensure the full and fair participation by all potentially affected communities in the transportation decision-making process.

3) To prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority and low-income populations.

These three principles account for disproportionate burdens, inclusive participation, and equitable receipt of benefits. These three components reflect procedural and outcome equity (Figure 1). Inclusive participation relates to procedural equity. Incorporating input from various populations, especially those with less political influence, into the planning process addresses equality in the process or procedures. The burdens and benefits are the results or outcomes of process and subsequently the transportation improvements. Procedural and outcome equity will be discussed in more detail later.

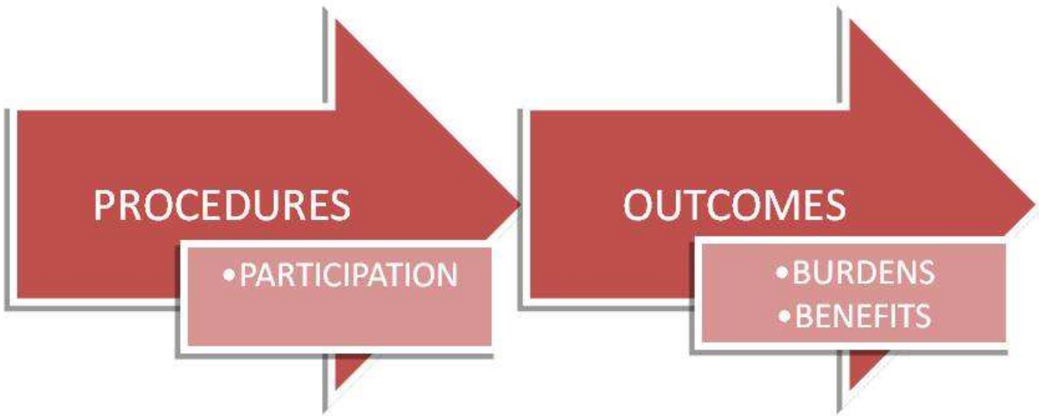

Figure 1 Illustration of environmental justice definition for transportation in terms of procedural and outcome equity

Although the USDOT Order and the FHWA and FTA memos provided additional guidance, a lack of explicit directives for state agencies remains. The lack of explicit directives does however provide agencies with some flexibility to implement environmental justice policies most applicable to the area context. Still this does not remove the oversight requirement from the regulating agency. For state DOTs, the FHWA and FTA monitor compliance with the EJ regulations. Typically, local agencies align their EJ programs with the state DOT and are, in that way, indirectly connected to the FHWA and FTA. This connection, however, may vary depending on the location and population size of a local community. For example, a rural municipality with a population of less than 10,000 may adopt their state DOT's environmental justice policies. However, in metropolitan areas, the Metropolitan Planning Organizations (MPO) may lead most of the planning activities and therefore become the primary point of contact for the federal agencies (Amekudzi et al., 2012).

Ultimately, all agencies must comply with the federal regulations of EJ and oversight requirements of Title VI and NEPA. Each agency must provide a Title VI compliance report annually. This report provides evidence of the activities that the agency has taken to meet the requirements of Title VI and EJ. Title VI compliance reporting can often be combined with, or at least aligned with, NEPA compliance. The

NEPA process requires documentation of all plan development processes undertaken by an agency receiving federal funds; this includes potential impacts on both natural and human resources and measures for mitigating such impacts. Through the NEPA process state and federal partners can review the impacts and mitigation measures for any federal process and produce one of three types of documents: a Categorical Exclusion (CE), an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). Environmental justice efforts are reviewed for compliance as a part of the review of Title VI and NEPA documents. In addition to document reviews, the federal government can assess the quality of an environmental justice program at certification reviews for MPOs and when auditing self-certification documentation for state and local agencies (Amekudzi et al., 2012).

While each agency oversees compliance among its state and local agencies, the Interagency Working Group on Environmental Justice (EJ IWG) is a federal oversight group. It was established under the Executive Order and that has been instrumental in previous environmental justice regulation development. This group was reconvened in the fall 2010 by the EPA and the White House Council on Environmental Quality to evaluate the performance of environmental justice to date with the intent to revise, improve and expand the environmental justice applications. Some of their goals are to promote “green jobs”, share best practices, and identify opportunities for improved environmental justice (EPA Website). In the summer of 2011, all federal agencies signed a memorandum of understanding agreeing to reevaluate their environmental justice practices and revised and distribute environmental justice strategies and implementation reports. At the end of February 2012, all federal agencies released this information. The USDOT strategy maintains the three goals outlined previously. The document provides an overarching vision for environmental justice in USDOT and pulls heavily from the 1997 DOT Order. The new strategy continues to allow flexibility to the operating administration and their state agencies but streamlines the USDOT’s approach to environmental justice for consistency throughout the Department. There is however, a greater emphasis on reporting and accountability as well as the addition of high priority program areas such as quality of transportation options for target populations, impacts and benefits from commercial transportation, and impacts from climate change (FHWA Website).

Procedures

The three goals of the USDOT remain paramount in the new strategy. As discussed previously, these goals can be seen as procedures and outcomes. Transportation planning must "ensure the full and fair participation by all potentially affected communities in the transportation decision-making process" to comply with the environmental justice executive order. Procedural equity addresses equity in the planning process, which is evident in this goal. The primary way to produce equity in the decision-making process is to incorporate all stakeholders, especially those who are marginalized, into the process. Given the history of environmental justice and the failure to include communities affected by transportation decisions, it is important to incorporate public involvement into the planning process to give a voice to those with less political power. Public involvement is a vital component for environmental justice and helps to produce procedural equity. The needs, values and concerns of all effected populations must be included in the process of planning, selecting, and implementing changes in the transportation system (Forkenbrock 2004).

Public involvement is the focus of many environmental justice programs in transportation (Forkenbrock 2004). This highlights the focus on procedural equity. Inclusion of all parties in the process leads to procedural equity. Although procedural equity influences the eventual outcomes, it does not necessarily result in equitable outcomes. This is exemplified in Arizona DOT's proactive analysis of their EJ program in 2002 (Jerome and Donahue 2002). Through benchmarking, ADOT determined that they were in compliance with the procedural components of environmental justice regulations and on par with peer agencies. However, low-income and minority communities voiced concern over the quantity of transportation options available to them, as well as potential negative impacts. ADOT's research effectively captures the need for using both procedures and outcomes to determine the efficacy of an EJ program. Outcome equity can be determined through quantitative analysis of distributive effects.

Outcomes

All transportation projects, plans and policies result in some impacts. These impacts have effects on the overall society and then have effects that are distributed across various populations of society. These impacts can either result in benefits or burdens for various segments of the population. A utilitarian approach would seek to provide the greatest good for the greatest portion of the population, however, this invariably means that some "lesser" portion will not receive the "good." To provide the greatest good for society, some members of society will not experience those benefits and may in fact experience a loss despite the net benefits for society. John Rawls's "A Theory of Justice" (1971) states,

"Each person possesses an inviolability founded on justice that even the welfare of the society as a whole cannot override. For this reason justice denies that the loss of freedom for some is made right by the greater good shared by others. It does not allow that the sacrifices imposed on a few are outweighed by the larger sum of advantages enjoyed by many. Therefore in a just society the liberties of equal citizenship are taken as settled; the rights secured by justice are not subject to political bargaining or to the calculus of social interest."

Criticizing the very basis of utilitarianism, Rawls's argument underlines the importance of identifying marginalized populations and determining how they are impacted by decisions for society. In a just society, each member has equal right to the total array of basic liberties available through a system that provides liberties for all. According to Rawls, primary goods of rights and liberties, powers and opportunities should be equally afforded to all (Hart 1974). While Rawls is generally vague in describing rights and liberties, they include those stipulated in doctrines such as the Bill of Rights (e.g. freedom of speech) and those afforded to citizens by law (e.g. public education). These liberties should be equally distributed across society. Although it can be philosophically debated whether the right to transportation is or is not one of these presupposed liberties (Martens 2011), if transportation is viewed as a means for social inclusion rather than an end, the case can more clearly be made that transportation should be viewed as a one of these liberties. This case is made later. The impacts of transportation decisions invariably affect society as a whole. These impacts have the ability to affect different segments of society to various extents. These impacts must be evaluated for their distributive effects on target populations.

Quantitative analysis of environmental justice outcomes evaluates the distribution of impacts across the population, especially across the target populations. The analysis requires the measurement of distributive effects. Distributive effects are quantifiable results that have differing effects across different members of the population (Forkenbock 2004). Effects are distributed spatially, temporally, and also across social groups (Forkenbock 2004).

These effects comprise both the burdens and benefits that result from transportation projects. In previous environmental justice practices, burdens became the primary focus of environmental justice assessments. Negative effects of air pollution and traffic are easily quantifiable, while benefits such as economic development are generally less tangible. Common practice focuses on the distribution of burdens; however, these should be weighed against the benefits of projects (Cambridge 2002). For example, a new road may contribute to noise pollution but it may also induce development for the area and provide more jobs for those living in the community. In addition, the distribution of those burdens and benefits must be evaluated. For example, a roadway may be constructed that provides access to an affluent community but not lower-income communities; however, lower-income communities will still pay for the road via taxes. The same is true vice versa. Therefore, it is necessary to assess the net distributive effect, and do so cumulatively. Finally, benefits should also be equally equitably distributed across the entire population. For example, the addition of a light rail line may increase accessibility for the northern part of a county but will have little or no effect on the southern part. The nature of projects is such that their impacts can be inequitable. However, the cumulative impact of projects must be deemed equitable by various stakeholders making it necessary for the system-wide and cumulative impacts of projects to be monitored and the results fed into decision making to ensure equity is achieved in the long run.

The effects are in essence the outcomes of transportation projects. It is important that outcomes are not solely examined in aggregate terms but are evaluated based on their impact on particular populations (Cambridge 2002). This disaggregate review allows the determination of distributive impacts.

Quantitative Analysis of Environmental Justice Outcomes

Based on the literature and case study reviews discussed later, environmental justice assessments can be broken into three steps: identification of the population and study area that will be impacted, determination of the impacts resulting from the transportation improvement, and an analysis of the distribution of impacts for disproportionality (Figure 2). This procedure is usually applied to projects.

Figure 2 Framework for quantitative analysis of environmental justice outcomes

Defining the Population

A pivotal component in analyzing environmental justice impacts of projects, plans and programs is delineating between who will be considered the target population and who will be considered the reference population. Determining the impacted population is also a vital component that is discussed in more detail when defining the study area.

Executive Order 12898 characterizes target populations as minority and low-income populations. The FHWA and FTA further define minority to include: Black, Hispanic, Asian, American Indian and Alaskan Native, and most recently Native Hawaiian or Other Pacific Islander. Low-income is defined as a household at or below the Department of Health and Human Services poverty guidelines. Given these definitions, target populations are "any readily identifiable group" of minority or low-income persons either living in geographic proximity or geographically dispersed (USDOT 1997). The consequence of defining target populations in this way is that impacts can have adverse effects on target populations even when they are not physically concentrated together. For example, a large city can have a low percentage of low-income households while a small town has a high percentage of low-income households. It is still possible for there to be more low-income households in the large city than the small town despite the high concentration of low-income households in the small town. Because of this, thresholds, which are often used in practice, may not adequately capture populations that are not concentrated in geographic proximity. Additionally, FHWA underscores the emphasis on disproportionately high adverse effects and not the size of the target population affected. "A very small minority or low-income population in the project, study, or planning area does not eliminate the possibility of a disproportionately high and adverse effect on these populations… Environmental Justice determinations are made based on effects, not population size. It is important to consider the comparative impact of an action among different population groups (USDOT 1999)."

Definitions of race, ethnicity, and low-income can be found not only on the federal level, but many MPOs and state agencies have also adopted clear verbiage to identify target populations. Subtle differences between definitions at a local level and those at the federal level can complicate environmental justice analysis. In addition, access to the necessary demographic data or lack thereof can complicate defining populations as prescribed. For example, FHWA requirements define low income as households at or below the poverty line; however, the Census Bureau reports the number of households below the poverty line and groups those at the poverty line with households above the poverty line (Hartell 2007). The Census also only provides income information to the block group level. Further complications are presented in evaluating households of multiple races and/or ethnicities and guidelines for counting these individuals and households differ based on jurisdiction. If all races and/or ethnicities are not counted, as in past censuses, there is a possibility that racial groups can be undercounted (Hartell 2007).

Data complications can arise when different data sources are used to assign definitions to a population. Data used to determine if a population can be categorized as disadvantaged can be drawn from sources such as the US Census Bureau or local or county tax authorities. Census data is most often used. However, with this, there are resolution concerns. Household travel surveys, activity-based models and microsimulations can reduce some data needs, in turn reducing the pressure on Census data (Duthie 2007).

It is also important to note that target populations refer to two groups, minority and low income and these groups "should not presumptively be combined (Cambridge

2002).” Although the elderly, disabled and child population groups are not explicitly addressed in the environmental justice regulations, these populations are also often considered in practice (FHWA Website). These groups are defined as target groups in the 2004 Executive Order 13330: Human Service Transportation Coordination and are included in FHWA policy (Cambridge 2002).

Defining target populations is a complex step and defining the reference population can also be a challenge. There is no clearly defined procedure for determining a reference population. The reference population can range from an aggregation of residents in all affected census units to a limited population of the census units contained within the affected area (Most 2004). Other determinants such as Metropolitan Planning Organization jurisdiction or tax service district can be used to define a reference population as well (Hartell 2007). The definition of the reference population has great implications for the analysis as the impacts on the target population will be compared to the impacts on this reference population. The reference population is tied to the study area that is defined. Defining the study area is discussed in greater detail later.

Scale of analysis

The geographic unit of analysis can have a substantial impact on the results of environmental justice assessments. Impacts and populations can be viewed at a geopolitical level such as the county, city or neighborhood, or Census divisions such as tract, block group or block levels or at other geographic units such as traffic analysis zones. An impact can be evaluated on some target population at various geographic units with dramatically different results. This is evidenced in studies evaluating the correlation between the siting of hazardous facilities and target populations. While some such studies have found negative correlation between the location of hazardous facilities and minority populations, others found a positive correlation. This contradiction is likely because of the geographic unit used in each evaluation. A study in Allegheny County, PA found that by altering the unit of analysis, the correlation between location of facilities and minority population changed. Using Census block groups, the study found that the proportion of minorities around hazardous facilities was lower than the proportion of minorities in other communities. However, the proportion of minorities within a half-mile radius of the sites is larger than those outside this area (Maantay 2002).

Census data, and most other demographic data does not account for densities within the unit of analysis. Instead they impose a continuous artificial spatial distribution of information across a geographic area and in effect, produce artificial spatial patterns. This is known as the Modifiable Areal Unit Problem (MAUP). The aggregation of data reduces the reliability of results (Maantay 2002). Because of the aggregation of data, the MAUP hinders acquiring accurate spatial representations of data (Duthie 2007). This artificial distribution leads to varying results at different levels of geographic units. The aggregation of data hinders high resolution applications and renders evaluations of impacts at aggregated levels almost meaningless because of the variation of demographics in the larger units of analysis. A similar issue arises in applying statistical correlations across varying scales of resolution (Amekudzi and Dixon 2001).

The ideal unit of analysis is small enough to contain fairly homogenous population demographics (Forkenbock 1997). Census tracts provide a group with similar demographic and socioeconomic characteristics, however, they still contain approximately 3,000 people and maybe spatially large. The Census block group and Census block are therefore the most attractive options; however, less data is available at these higher resolutions (Forkenbock 1997).

Defining the Study Area

In defining the study area, the reference population is also defined. As mentioned previously, there are a variety of options for the reference population. The reference population can refer to the total population in the study area or have a larger breath and refer to state or regional areas. It is important to remember when defining the study area that this is not solely about the geographic bounds of the impacts but also about determining the impacted population.

The general methodology for defining a study area assumes that the environmental justice assessment is conducted on a project level. Potential impacts are estimated and the bounds of these impacts are used to inform the study area delineation. The bounds of the impacts may produce a buffer zone surrounding the project that can be estimated at a set distance (Hartell 2007). Census tracts or other geographic units around the physical transportation project area are identified and analyzed for impacts. This is a straightforward method for considering impacts resulting from physical transportation improvements; however, it presents problems for transportation policies that have no geographic reference or environmental justice impacts that are not constrained to physical bounds.

Additional complications lie in the spatial distribution of Census data and the MAUP. Aggregation of information into low resolution census blocks or block groups forces demographic information such as race and income to be blanketed across an area, neglecting the true demographic distribution of the area. Compounding this, community and neighborhood boundaries are not likely contiguous with Census units. Therefore, when analyzing impacts within a community or neighborhood, the manipulation of data can lead to additional misrepresentations (Hartell 2007). Also, defining a single study area assumes the entire population within the given area is affected equally and that the population outside of that area is not affected (Chakraborty 2006).

Current methods to define the study area for environmental justice assessments grapple with these issues. These methods vary and produce a range of results. Judgment must be used to decide the most effective process for a given case with the goal of ensuring equity outcomes for the target populations impacted. Four methods to define the study area are polygon, within, centroid, areal interpolation and cross-area transformation.

Buffer Zone

As mentioned previously, a buffer zone may be delineated first. This is a zone within a specified distance from the transportation project for which the analysis is being conducted. The buffer zone(s) represents the assumed area that will experience actual effects (Hartell 2007). Multiple buffers at varying distances from the project can be established to examine the differential of potential effects at varying distances (Hartell 2007). However, because the buffer zone is defined at a constant distance surrounding the project, it is unlikely that Census tracts or other predefined geographic units will correspond exactly. The four methods outlined previously address this issue.

Polygon Analysis

Polygon Analysis can also be referred to as Adjacency Analysis. It is methodologically simple. In this analysis, all census units within or intersected by the project (or the buffer of the project) are included. Despite the ease of determining the study area in this methodology, it may extend the study area far beyond the bounds of the buffer and the methodology also has the possibility of excluding areas close to the buffer (Hartell 2007). Figure 3 depicts the principle of polygon analysis. Note that block groups directly to the south of the project area have been excluded when the buffer is 500 feet or less, however, the large block group to the southwest is included in the analysis.

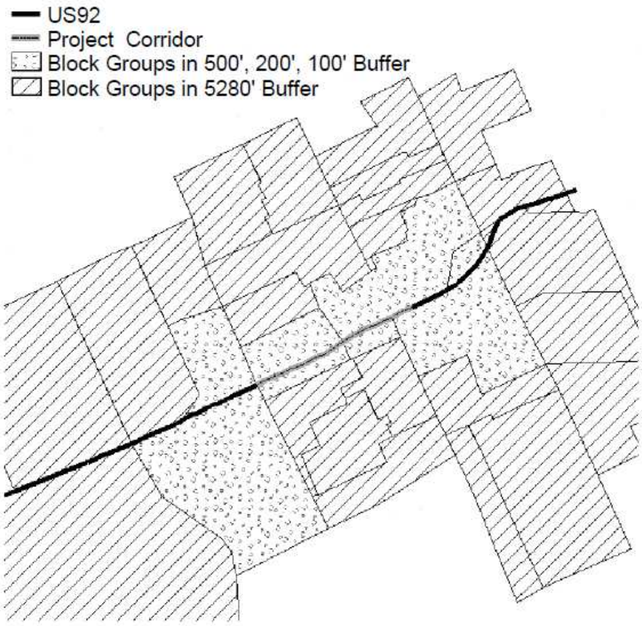

Figure 3 Polygon Analysis showing how some areas close to the project can be neglected while those farther away from the project are included (Source: Hartell 2007)

Within Analysis

Within Analysis requires a similar effort level to the Polygon Analysis. In this method, only census units contained entirely within the buffer are analyzed (Most 2004). This leads to obvious disadvantages. Census units in which a majority of the population lives within the buffer may be excluded if a portion of the unit is outside the limits of the buffer. Figure 4 depicts the principle of Within Analysis. Note that using smaller buffers excludes many of the surrounding census units. Also, cases like Figure 4 show that if the units are not completely contained in the buffer, they will not be included in the analysis.

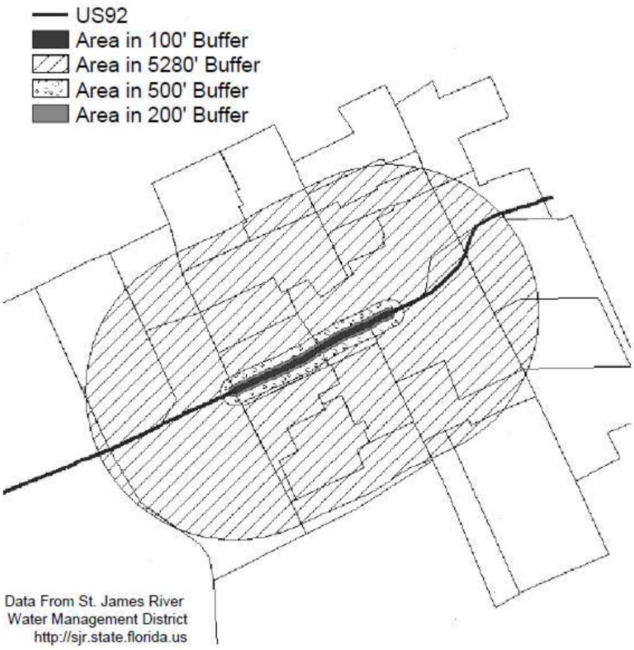

Figure 4 Within Analysis illustrated with different buffers showing that smaller buffers would exclude several of the surrounding census units (Source: Hartell 2007)

Centroid Analysis

Centroid Analysis has similar drawbacks to Within Analysis. In this method, it is assumed that the population is concentrated at the centroid of the census unit and census units are included in the study area if the geometric centroid of the unit is within the buffer area. Like Within Analysis, it is possible to exclude populations that are actually within the buffer and yet have centroids outside the buffer (Hartell 2007). In addition, it is possible for this method to exclude areas directly adjacent to the project. Figure 5 depicts the principle of centroid analysis. Note the block groups surrounding to the eastern end of the project corridor that are not included in the 500-foot buffer.

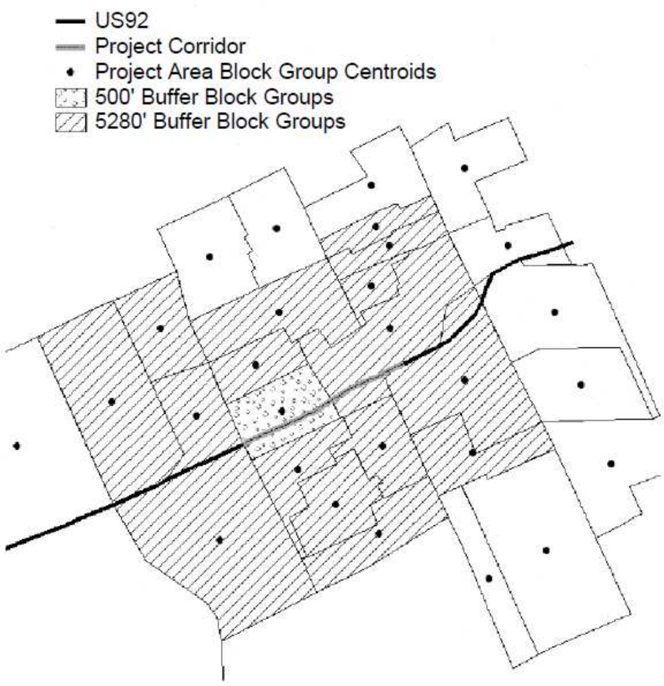

Figure 5 Centroid Analysis depicting units that are included in the study area have their geometric centroid falling within the buffer area (Hartell 2007)

Mathematical Transformations

Mathematic transformations overcome the limitations of the previous methods by including partial geographic units (Chakraborty 2006, Most 2004). These methods apportion demographic information to fractions of census units, imposing assumptions about the spatial distribution of the population within census units in order to create a demographic profile for the defined buffer zone. These techniques, also referred to as Buffer Containment by Chakraborty (2006), rely on the assumption that demographics are evenly distributed across the census unit. Two methods of mathematical transformation are Areal Interpolation and Cross-area Transformation.

Areal Interpolation

Areal interpolation assigns a percentage of the intersected census unit's population to the buffer zone. This percentage is equivalent to the percentage of area of the census unit within the buffer zone. The demographics of that assigned population mirror the demographics of the entire census unit. Most (2004) provides the following formula:

$$P = \sum_{i=0}^{n} P_i + \sum_{j=0}^{m} \left[P_j \left(\frac{A_{je}}{A_j} \right) \right]$$

where:

P = total population inferred through the interpolation

n = number of census units contained entirely within the buffer

Pi = population of intact census unit

m = partial census units

Pj = population corresponding to partial census unit

Aje = the partial area of truncated census unit

Aj = the total area of the truncated census unit

Cross-Area Transformation

Cross-area transformation ascribes demographics information from the census units fully contained within the buffer to the partial units. The census units fully within the buffer zone are referred to as the source zone. Cross-area transformation determines the percentage of the buffer zone that is the source zone. The remaining area of the buffer zone, the target zone, is the area of the partial census units within the buffer zone. Cross-area transformation assigns the demographic information of the source zone to the target zone based on the area of each partial unit within the buffer. Cross-area transformation calculates the percentage of the buffer zone that each partial census unit occupies and based on this percentage, a population is estimated and demographics from the source zone are applied. This assumes that the demographic information of the census units within the buffer adequately reflect the characteristics of the population within the buffer zone (Most 2004). Most (2004) provides the following formula:

$$P = \sum_{i=0}^{n} P_i + \sum_{j=0}^{m} \left[P_{ix} \left(\frac{A_{je}}{A_j} \right) \right]$$

where:

P = total population inferred through the interpolation

n = number of census units contained entirely within the buffer

Pi = population of intact census unit

m = those partial census units

Pix = total population of buffer zone based on source zones

Aje = the partial area of truncated census unit

Aj = the total area of the truncated geographic unit.

Table 1 summarizes the advantages and disadvantages of the afore-mentioned methods for determining the study area.

Table 1: Summary of Methods for Determining Study Area

Method	Advantages	Disadvantages
Polygon	• Clear and simple method	• Disregards distance decay because it may extend far beyond the bounds of the project buffer • Has the possibility of excluding areas close to the buffer
Within	• Clear and simple method	• Populations within buffer may be excluded if census unit is not fully contained within buffer
Centroid	• Less likely to include populations in Census units that extend far beyond the buffer	• It is possible to exclude areas adjacent to the buffer or populations that are within the buffer depending on location of centroid
Mathematical Transformations	• Translate demographic information to an area within the buffer zone	• May neglect areas of high concentration outside of buffer (minimized when small geographic units are used)

Determine Impacts

The outcomes of transportation projects, programs, or policies provide benefits and may result in burdens to the general population. As one can imagine, there is a plethora of possible impacts from these benefits and burdens. Natural environmental concerns such as air quality and noise pollution impacts are often evaluated by transportation agencies for environmental justice assessments. Transportation user effects such as increases or reductions in service or changes in safety are also important indicators of environmental justice (Forkenbrock 2004). One such transportation user effect is accessibility. Accessibility is becoming more widely recognized as a critical issue with the sprawling, automobile-centric development of the American metropolitan areas and suburbs (Kawabata 2007). Accessibility to critical services, jobs, schools, and other daily necessities are basic needs. Accessibility to parks, libraries and cultural institutions allow populations to participate in society. These destinations can be viewed as opportunities for social inclusion. Drawing upon the DOT Order and Rawls's theory of justice, all segments of the population should have equitable access to these opportunities. Access to these opportunities is a benefit of transportation but social inclusion can be seen as a liberty or primary good. It is this access that the transportation system provides. Disparate accessibility to such destinations across various portions of the general population is therefore an important concern and can be viewed as an inequitable outcome of cumulative transportation investments.

Social Inclusion is a term frequently used and studied in the United Kingdom; however, it is not often used in North America (Lucas 2004, Solomon and Titheridge 2009). In a comparative study of seven nations, Kennedy (2003) for the Fédération Internationale de l'Automobile (FIA Foundation) made the clear link between social inclusion and environmental justice in the United States. Transportation policies that enable prohibitive costs of transportation, reliance on automobiles, or neglect cumulative effects restrict social inclusion for some segments of the population, namely those that cannot afford high transportation costs. A recent study showed that state transportation agencies in the U.S. have focused more on the burdens than benefits of transportation investments in addressing environmental justice and most do not address cumulative impacts (Amekudzi et al., 2012). Environmental justice policies in transportation have the goal to "prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority and low-income populations (USDOT 1997)." One such benefit is accessibility and the access to opportunities that allow social inclusion.

Social inclusion coincides with mobility, the ability to physically be mobile and access destinations (Litman 2003). This mobility is facilitated through an accessible transportation system. A household may not have a car and hence may have limited mobility. If they live within walking distance from work, school, and a grocery store, however, they have a high level of accessibility. In this way, accessibility is a limiting factor in social inclusion. Reduced accessibility results in a reduced ability to reach destinations that provide opportunities to participate in society. This reduced participation can then also translate into a denial of liberties.

In addition to social impacts, the differences in accessibility can have economic and political repercussions (Bohon 2008). Not only is accessibility necessary for social inclusion, but it also has economic impacts on individual households. Urban economists use accessibility as a prime determinate for property values and utility (Sanchez 1998). It has also been argued that jobs in low-income communities are low-paying low-skill jobs with limited opportunities for upward advancement (Bohon 2008) and limited accessibility makes these jobs the primary option for residents in these communities, making them captive workers in dead-end jobs. Limitations for participating in the political process, including public meetings required by environmental justice policies, Title VI, and NEPA can also result from reduced accessibility.

The accessibility difference between automobiles and public transit is especially relevant to environmental justice as a large population of the transit captive population is low income and many are minority. To determine how the target population in the study area is impacted, the distributive effects must be quantitatively measured. The following is a discussion on measuring accessibility.

Accessibility

Accessibility is an extremely broad topic and has a wide range of applications. In general, accessibility can be understood as the opportunity to reach goods, services and other destinations. However, the definition for the term “accessibility” varies across different disciplines. Roadway engineering views access as the physical connection to adjacent properties through intersections and driveways. Facility design refers to accessible design as that which accommodates users with disabilities. In transportation planning, accessibility refers to ease with which people can reach a desired destination. This ease is a function of the transportation system and the land use patterns; the location of destinations and the transportation network available to reach these destinations determines the accessibility of an area (Litman 2011). In the same way that accessibility has numerous applications and definitions, its breath also leads to numerous methods to measure accessibility. Even when confining the understanding of accessibility to the ease of reaching goods and services, there is still a suite of methods that can be applied to determine accessibility. A commonality in methods used to measure accessibility is that they account for “opportunities.” These are the goods, services, activities and destinations that people seek to reach (Litman 2011). However, the level of sophistication varies among methods.

Measuring Accessibility

Conventional Methods

Accessibility has conventionally been measured using gravity models. The gravity model is adapted from Isaac Newton’s Law of Gravitation. The premise is that attraction is proportional to the mass of two objects and inversely proportional to the distance between the two objects. In applying the Law of Gravitation to accessibility, the “mass” can be translated into the trip production (origin)/attraction(destination) of a location. The “distance” can be translated literally or it could be applied as travel costs, travel time or some other generalized cost. In this way, the “gravitation” or accessibility between two locations can be given as a function of production and attraction between two locations over the generalized cost to travel between them.

$$Gravitation = \frac{f\ (P_i, A_j)}{f(c_{ij})}$$

By constraining only the attraction to zone *j*, and assuming productions from any and all zones, the equation becomes less of a gravitation between two locations and becomes more of a measure of attractiveness of one zone from all other zones. This can be represented by:

$$Attractiveness = \frac{A_j}{c_{ij}}$$

As distance (cost, time) between two locations becomes increasingly small, a simple measure of distance will cause the equation to approach infinity. The generalized cost function therefore is conventionally taken as an exponential function of the cost.

$$Attractiveness = \frac{A_j}{e^{\beta c_{ij}}} = A_j e^{-\beta c_{ij}}$$

where β is a cost sensitivity parameter (Geurs 2004, Ned Levine and Associates 2004). Accessibility can be measured as the total attractiveness for all locations within zone j. If the relative attractiveness of a zone is measured by the number of opportunities (so that a_j is an opportunity in zone *j*),

$$Accessibilty = Acc = \sum a_j e^{-\beta c_{ij}}$$

This is the standard form of the gravity model for measuring accessibility. A basic version of the gravity model is cumulative opportunity. Cumulative opportunity is a summation of attractions within an area constrained by some generalized cost. Cumulative opportunity, however, does not incorporate this cost into the measure of accessibility. It assumes that all opportunities within the zone have the same attractiveness. Rather than using the impedance function, cumulative opportunity uses a simple weighting factor (*W*) in:

$$Acc = \sum W a_j$$

The weighting factor is either 1 if an attraction is within the cost limit or 0 if it is outside the cost limit. Using the equation above, it is clear that this will result in the total of opportunities in zone j. This provides no weight of attractiveness for each destination based on the generalized cost. The general gravity model accounts for the generalized costs through the negative exponential function of the equation, otherwise referred to as the impedance function. The impedance function in the form of the negative exponential not only addresses issues with very close locations but also associates well with travel behavior (Geurs 2004).

The result of the gravity model is a summation of destinations weighted based on some form of generalized cost. Still, the gravity model provides a simplified method for measuring accessibility. Both the gravity model and cumulative opportunity follow the conventional mindset based on spatial logic. This mindset views accessibility as an attribute of places rather than of people (Kwan and Weber 2003). The gravity model accounts for the opportunities that are available to the user but neglect factors such as individual preferences or temporal conditions (Dong et al. 2006). It also excludes the effects of competition amongst opportunities. In addition, conventional methods may also be less accurate if they account for Euclidean distance rather than distance constrained to the existing transportation network.

Another major drawback of conventional methods is the zonal focus. Intrazonal trips are often excluded from conventional methods of measure. This causes walking and cycling trips to be neglected in accessibility measures. Modifications can be made to account for intrazonal trips. Impedance functions can be customized to reflect trips using different modes, including walking and cycling. This was done by Iacono et al. (2010) for the Minneapolis metropolitan region. In this study, impedance functions were customized based on mode and trip purpose (i.e. work, shopping, school, restaurant and recreation) using historic trip data and the location of attractions. However, despite the ability to measure accessibility by one specified mode, conventional methods do not account for the multi-modal nature of actual travel.

Advanced Methods

Conventional methods for measuring accessibility do not account for individual differences, even when disaggregate level data is used (Kwan and Weber 2003). In addition, even when accessibility is measured at various scales (e.g. local, regional, state) reconciling the results into an aggregate measure is very complex, if even possible. Measures that account for individual preferences are more sophisticated than the gravity model allowing accessibility to be measured on an individual level. They are more able to represent complex human spatial behaviors and the actual urban environment. Conventional methods also neglect temporal considerations. They do not account for scheduling of events, traffic congestion, changes in transit schedules or patterns of business hours (Kwan and Weber 2003). Space-time measures on the other hand, are based on personal and social constraints and take a person-based perspective. These measures account for individual preferences and temporal conditions. Furthermore, MAUP is not a problem with space-time measures in the way that it is with aggregate measures because the measures have little to no relation to distinct geographic scales (Kwan and Weber 2003, Neutens 2010).

Other advanced methods include models based on utility theory. The utility derived from a destination guides this approach; however, it is not possible to know with certainty what this utility will be. Using random utility theory, an accessibility measure can employ multinomial logit models to capture individual preference (Dong 2006). Activity-based accessibility builds upon random utility and incorporates the range of activities pursued throughout the day, the schedule of these activities and accounts for trip-chaining by using a day activity schedule to model the all trips that an individual takes in a day (Dong 2006).

There is an increasing number of measures that provided a more comprehensive understanding of accessibility, accounting for mode, activities schedule and individual choices. As distance becomes less of an indicator for accessibility (Kwan and Weber 2003), more advanced methods are necessary to measure it.

Components and Perspectives of Accessibility Measures

Accessibility can generally be viewed as a measure of people or a measure of places (Halden 2005). A categorical approach identifies with the travel patterns, preferences and needs particular social groups. A spatial approach relates to the characteristics of transportation use in various general areas. Further distinguishing accessibility measures, theoretically, there are four components of accessibility that should be addressed when measuring accessibility: land-use, transportation system, temporal conditions, and individual preferences (Geurs 2004). The land-use component depicts the spatial distribution of opportunities and destinations, the demand for these opportunities and the competition between the destinations. The transportation component reflects the generalized transportation costs experienced between an origin and destination using a specific mode. The temporal component describes the time sensitivity of opportunities and their availability throughout the day. The individual component depicts the needs and abilities that influence travel. Each of these components should ideally be accounted for in accessibility measures however, application of all would be very complex and impractical. Accessibility measures in practice generally address one or more of these components based on the perspective that is taken.

Four basic perspectives were identified by Geurs (2004): infrastructure-based, location-based, person-based and utility-based. An infrastructure-based perspective to accessibility focuses on the potential mobility of the system, the level of service of the transportation network. A location-based perspective measures accessibility based on the spatial distribution of opportunities, generally on a macro-level. A person-based perspective accounts for an individual's time budgets and schedule. Lastly, a utility-based perspective approaches accessibility from the benefits that are derived from the opportunities.

Viewing accessibility as an attribute of places through an infrastructure- or location-based perspective can be considered a spatial approach. This approach can be useful in analyzing travel behavior based on the urban form of an area (Halden 2005). However, activity patterns vary between social groups and even within geographic boundaries. A category approach views accessibility as an attribute of people through a person-based perspective. This approach helps to analyze select social groups within an area-based framework (Kwan and Weber 2003). However, social groups differ from location to location. Halden (2005) suggests using a combination of the two approaches to assess accessibility. Approaching accessibility both spatially and categorically can address multiple components by measuring accessibility using various perspectives. Table 2 categorizes the accessibility measures described into their corresponding perspectives. The conventional cumulative opportunity and gravity methods take a location-based approach and incorporate land-use and transportation components. Individual measures like space-time have a person-based perspective and account for both temporal and individual components of accessibility. Random utility theory models obviously have a utility-based perspective and account for transportation, land use and individual components. Activity-based models using random utility also account for the temporal component. Advanced methods are continually being developed and modified that view accessibility through different lenses and account for temporal conditions and individual preferences.

Table 2: Summary of Accessibility Measures

Method	**Perspective**	**Description**	**Advantages**	**Disadvantages**
Cumulative Opportunity	Infrastructure-Based Location-Based	$A_j = \Sigma W_j a_j$ where: A_j = Accessibility of zone j W_j = weighting factor a_j = attractions in zone j	- Meets transportation system criteria - Easily computed and interpreted	- Does not account for land use patterns, temporal constrains or individual needs - Neglects costs and power of attraction - Highly susceptible to the weighting factor chosen
Gravity Model	Infrastructure-Based Location-Based	$A_j = \Sigma a_j f(c_{ij})$ where: A_i = Accessibility of zone j a_j = attractions in zone j c_{ij} = generalized cost	- Meets both transportation and land use criteria - Useful for area-based, aggregate analysis of social groups	- Does not account for temporal constraints or individual needs - Excludes competition effects - Analysis at different scales (i.e. local, regional) cannot be combined
Space-Time	Person-Based		- Generally meets all criteria - Frameless (MAUP not applicable)	- Data intensive - Require complex algorithms and GIS expertise - Difficult to aggregate for evaluation of groups
Random Utility	Utility-Based	$A_j = \frac{1}{\lambda} \ln(\Sigma e^{\lambda V})$ where: A_i = Accessibility of zone j λ = scale parameter V = systematic composition of utility	- Meets both transportation and land use criteria and also individual needs - Can capture all modes	- Does not account for temporal constraints - Complex math required
Activity-Based	Utility-Based		- Meets temporal constraints - Takes trip chaining into account	- Complex math required

Analyzing Disproportionality

The final component of quantitative analysis of environmental justice outcomes is evaluating the effect for comparative differences between target populations and reference populations. After the target population and study area are identified and the impact upon this population is determined, in this case, the level of accessibility, the level of accessibility (or other impact) must be evaluated based on the population it affects in proportion to the general reference population. Rational method indices and methods using fixed proportions and thresholds may be used to assess disproportionality.

Proportional indices are referred to as rational methods by Hartell (2007). Two of these rational methods are the Buffer Comparison Index (BCI) and the Area Comparison Index (ACI). The BCI measures whether the population within the impacted study area has an overrepresentation of the target population in comparison to a larger geographic region (Chakraborty 2006). The following ratio of ratios is used to determine this:

$$BCI = \frac{\text{Target population in study area}/\text{Total target population in reference area}}{\text{Unprotected population in study area}/\text{Total unprotected population in reference area}}$$

The Area Comparison Index (ACI) is similar and also tests for overrepresentation in the study area; however it uses two mutually exclusive groups. This method compares the population within the study area to the population not within the study area (Chakraborty 2006). The following ratio of ratios is used to determine this:

$$ACI = \frac{\text{Target population in study area}/\text{Total population in study area}}{\text{Target population outside study area}/\text{Total population outside study area}}$$

For both indices, if the index is greater than 1, there is an overrepresentation of the target population in the study area. A two-sample test of proportions (one-tailed) can determine the statistical significance of the disproportionality.

Other methods used are based on fixed proportions. One such method to determine disproportionality is the Standard Deviation method. The Standard Deviation method calculates the percentage of the target population in the impacted study area and compares this to the mean of the reference area. If the percentage of target population within the study area is more than one standard deviation from the mean of the reference area, then the target population is overrepresented. Another method based on predetermined proportions is the Plus-25% method. This method establishes disproportionality by determining if the census unit has a protected population 25% greater than the reference population (Hartell 2007). This is an example of a threshold method. Other simpler thresholds may be set also (e.g. 50% of the study area population is target population). The standard deviation, Plus-25% and other fixed proportion threshold methods have the potential to neglect small, highly concentrated, disadvantaged groups. In addition, when comparing study areas, the results of these methods can be misleading. A small population containing a certain amount of disadvantaged households will have a percentage higher than a larger population with the same size of disadvantaged population. This can cause some disadvantaged populations to be neglected. Table 3 summarizes methods for determining disproportionality, with their advantages and disadvantages.

Table 3: Summary of Methods for Determining Disproportionality

Method	Advantages	Disadvantages
Rational Comparison **(BCI & ACI)**	• Flexible (ability to compare within study area or to outside area) • Based on area population and not arbitrary threshold • Simple mathematical calculations	• Highly sensitive to inaccuracies of data • No defined threshold built into test
Standard Deviation	• Defined threshold relative to area population • Simple mathematical calculations	• Potential to neglect small highly concentrated disadvantaged groups • Mathematical logic could be difficult to explain to those without knowledge of basic statistics
Plus-25%	• Defined threshold through use of fixed proportions • Easily comprehended by non-technical audience • Simple mathematical calculations	• Potential to neglect small highly concentrated disadvantaged groups • Least rigorous • Arbitrary threshold

CHAPTER 2

CASE STUDY REVIEW

Metropolitan Planning Organization Case Studies

Several Metropolitan Planning Organizations have incorporated accessibility in the environmental justice analyses. Table 4 – Table 8 below summarize important elements of environmental justice analysis for a number of MPOs that are evaluating accessibility within their quantitative analysis of environmental justice.

Table 4: Boston Region Metropolitan Planning Organization Environmental Justice and Accessibility Analysis Method

Boston Region Metropolitan Planning Organization (BRMPO)		
Defining the Population	**Minority**	Population more than 50 percent nonwhite or Hispanic
	Low-Income	Median household income at or below 60 percent of the median income for the region
	Other	
Defining the Study Area	TAZs; Identified 28 EJ areas composed of multiple contiguous TAZs (15 municipalities and 13 neighborhoods)	
Determining Impacts	Accessibility is defined "in terms of average transit and highway travel times from environmental justice areas to industrial, retail, and service employment opportunities; health care; and institutions of higher education. In recent work, the analysis of transit travel times included destinations within a 40-minute transit trip, and the analysis of highway travel times included destinations within a 20-minute auto trip. The accessibility analysis also included an examination of the number of destinations within a 40-minute transit trip and a 20-minute auto trip. (BRMPO website)" The 40-minute transit trip and 20-minute highway trips was based on Census Journey-to-Work data and represent average commute times in the region. Time-opportunity based. Opportunities are destinations such as industrial, retail, service jobs and universities and critical services including hospitals. Analyze the long-range build network as compared to the no-build (current) network.	
Determining Disproportionality	Accessibility results are compared between the build and no-build network and also compared between EJ and non-EJ areas for transit and highway travel. Results of destinations within travel time buffers are summed for EJ and non-EJ areas and averaged by the number of EJ and non-EJ TAZs.	

Table 5: Mid-Ohio Regional Planning Commission Environmental Justice and Accessibility Analysis Method

Mid-Ohio Regional Planning Commission (MORPC)		
Defining the Population Averages of study area were used as a threshold to identify target areas	**Minority**	Nonwhite or Hispanic
	Low-Income	Households at or below DHHS poverty line
	Other	Elderly (65 or older); Disabled (sensory or physical); Households without automobiles (Demographic information taken from 2005-2009 American Community Survey)
Defining the Study Area	Transportation analysis zones Using TAZs allow demographic information to be integrated with travel demand models Target areas were identified based on high densities of target populations Equivalency between census block groups and TAZs was developed	
Determining Impacts	Jobs within a travel time buffer: peak period automobile and transit times and off peak transit travel times are estimated from each TAZ to each other TAZ. The total jobs within 20 minutes auto and 40 minutes transit is calculated and a weighted average of jobs based on the population of each TAZ is calculated. Total shopping trips attracted in a 10 minute auto and 20 minute transit travel time buffer is normalized over the population of each TAZ. The same is done for non-shopping (doctors, bank, eating out, etc) with 20 minute driving and 40 minute transit thresholds. The percentage of the population within 20 minutes driving and 40 minutes transit of a college or hospital is also calculated. The percentage of the population within 10 minutes driving and 20 minutes transit of a major retail destination. Opportunity-based measures are used. Travel times are also estimated based on travel demand models including average travel time to CBD and transit accessibility to CBD.	
Determining Disproportionality	Target groups compared to non-target population for each accessibility measure. The current state is compared with the future no build and the future TIP implementation. Changes (added benefits and burdens) are examined.	

Table 6: National Capital Regional Transportation Planning Board Environmental Justice and Accessibility Analysis Method

National Capital Regional Transportation Planning Board (NCRTPB)		
Defining the Population Thresholds are set by the regional proportion of each	**Minority**	African-American/Black, Asian American, Hispanic
	Low-Income	Household income less than one and a half times the poverty threshold
	Other	Disabled; Elderly (over 65); Limited English

target population		Proficiency (the US 2010 census and 2005-2009 ACS)
Defining the Study Area	As NCRTPB uses census data, block or block group can be assumed to be the unit of analysis	
Determining Impacts	Number of jobs within 45 minutes via automobile or transit	
Determining Disproportionality	Projected changes in accessibility are estimated and the changes are analyzed across target populations and the across the region as a whole	

Table 7: Southern California Association of Governments Environmental Justice and Accessibility Analysis Method

Southern California Association of Governments (SCAG)		
Defining the Population	**Minority**	50 percent of tract is non-white
	Low-Income	Households at or below DHHS poverty level (based on DHHA level for region's average household size; Income broken into quintiles)
	Other	
Defining the Study Area	Transportation Analysis Zones; Demographic Census data translated through mathematic transformations	
Determining Impacts	"[Accessibility] is determined by the spatial distribution of potential destinations, the ease of reaching each destination, and the magnitude, quality and character of the activities at the destination sites." Opportunity-based measures are used. The percentage of opportunities (service jobs – banks, health services, auto repair, police and fire departments, social services) within 45 minutes is determined by taking the number of jobs in each TAZ and dividing this by the total number of jobs in the region. A similar analysis is done for parks (park acreage within 45 minutes). A ratio is developed based on trip making rate and income and trip making rate and mode for each county. This is based on PUMS data.	
Determining Disproportionality	The percentage of opportunities is compared across all minority groups and across all income quintiles for both modes. This is done for the current baseline situation and for the Regional Transportation Plan. The change is also evaluated over all groups. A monetary analysis is conducted. Values determined through modeling and current project cost estimates for the planning period. Appropriate distribution of benefits – an equal share for all groups, when appropriate, or a more beneficial outcome for lower-income groups where redistribution is desired – is determined.	

Table 8: Puget Sound Regional Council Environmental Justice and Accessibility Analysis Method

Puget Sound Regional Council (PSRC)		
Defining the Population Thresholds are the proportion of the target population in the region	**Minority**	Non-white
	Low-Income	Households at or below DHHS poverty level
	Other	Elderly; Disabled; Limited English Proficiency (Census data (PUMS) are used)
Defining the Study Area	Map transportation projects/ improvement corridors; Determine intersection of buffer zone and census units	
Determining Impacts	Uses travel demand model for forecasts of access to jobs and activity centers	
Determining Disproportionality	Fix proportions based on regional targets	

Census data is commonly used among MPOs to inform analysis of target populations. Decennially census data was used by all MPOs for developing baseline demographic profiles and in demographics analysis. Census data can be used with mathematical transformations to define a study area. SCAG translates census data through mathematical transformation in its noise assessments to apply demographic information to smaller divisions contained within residential zones to determine the target population within areas that surpass a decibel threshold. Census data is also used in defining disproportionality. Some of the MPOs that were reviewed (i.e. MORPC and PSRC) established “thresholds” using fixed proportions based on regional demographics. MORPC and PSRC considered geopolitical units with minority populations greater than the regional average to be target areas.

MORPC geographically interpreted census data with GIS for graphic analysis of target populations. PSRC’s project level environmental analysis relies on geographic information. The analysis follows the Polygon Analysis method. As such, projects are enclosed in a 100 foot buffer zone. If any portion of a census unit is within this buffer zone, the census unit is considered in the study area. This analysis is dependent on the use of GIS. MORPC also uses GIS to define geopolitical units that qualify for environmental justice analysis based on their population demographics.

GIS is used by all of the MPOs to map attractions for accessibility analyses. MORPC uses GIS to assess impacts on other performance measures as well. MORPC's graphically depicts congested VMT using GIS to provide a geographic reference for this performance measure. It also allows forecasted congestion increases to be compared visually against TAZs with high percentages of target populations.

Travel demand modeling is another tool that influences environmental justice analyses. Since MPOs focus on regional planning, emphasis is placed on future travel patterns. SCAG uses travel demand modeling to project trip distributions and mode splits for accessibility analysis. MORPC derives its environmental justice performance measures from the travel demand forecasting model process (e.g. average number of job opportunities, percent of VMT congested, average travel time to shopping, pedestrian facilities). Similarly, MPOs use future effects on air emissions, noise, and accessibility modeled by travel demand forecasts in determining the potential impacts on target populations.

The examples above help to elucidate the uses of environmental justice analysis tools in the quantitative analysis framework.

Atlanta Regional Commission Environmental Justice Assessment Strategy

In 1999, the Atlanta Regional Commission (ARC) established the Environmental Justice Planning Team to advise and guide ARC planning, projects and policies in relation to their effect on minority and low-income populations. Now called the Social Equity Advisory Committee, the group also gives consideration to elderly, children and disabled populations. The committee comprises members of community organizations, educational institutions, environmental organizations, local government and the ARC Board (ARC website). The committee's first active engagement was in the Mobility 2030 planning process and it has since conducted extensive outreach efforts and implemented technical assessment processes to evaluate transportation needs for minority and low-income populations in the Atlanta region (ARC 2006). The Social Equity Advisory Committee was also involved in the Plan 2040 process. A workshop was held in early 2010 to share the initiatives of the plan and receive input from advocacy groups. One of the focal topics was accessibility (to jobs and to transportation) (ARC website).

Defining the Population

The Atlanta metropolitan area is racially diverse and over the last ten years has seen an increase in the percentage of non-white ethnicity categories across the board (US Census). However, the racial diversity of the region as a whole if constrained to various geographic locations throughout the region and many areas across the region are very homogenous.

In past planning cycles, ARC defined environmental justice populations as Black, Asian, Hispanic and low-income populations. When a Census block group contained a target population percentage greater than the average target population for the region, that block group was deemed an environmental justice area. Figure 6 shows the environmental justice areas for 2006 (ARC 2006).

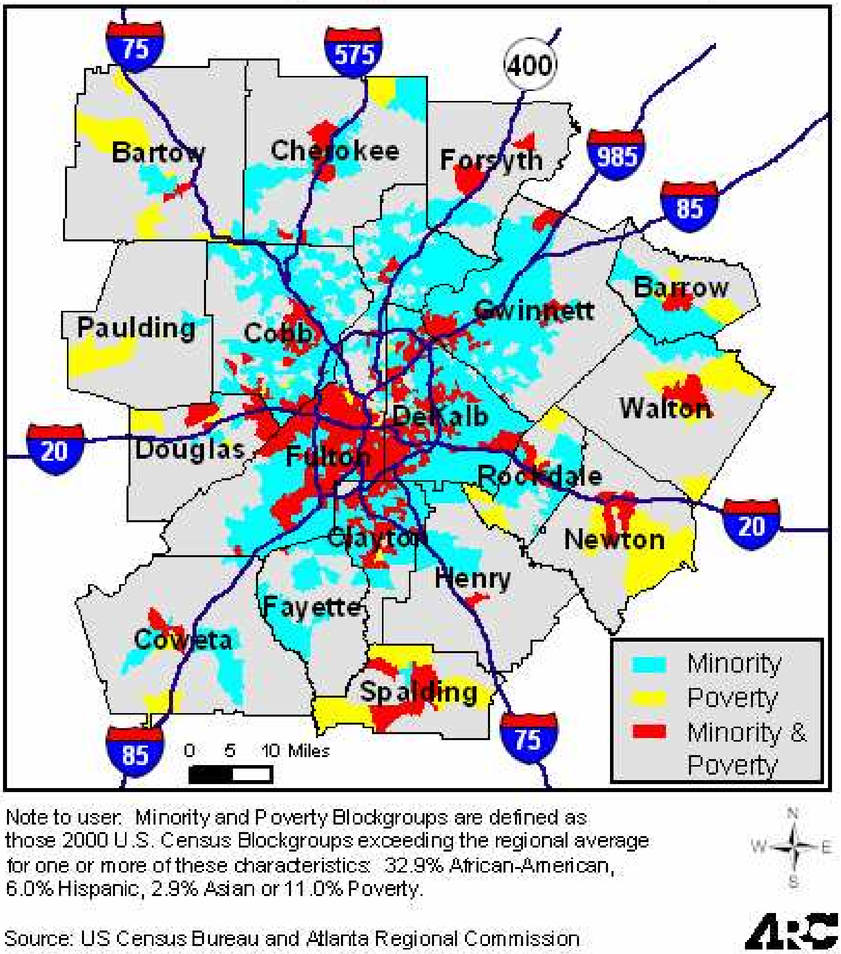

Figure 6 Environmental Justice Areas for the Atlanta Regional Commission 2006

In 2007, a consultant team was hired by the Commission to address ARC's concern that some areas deemed as EJ areas were not necessarily experiencing a disadvantaged quality of life. The consultants developed the Community Attribute Index that evaluates a number of weighted variables along five dimensions. The CAI was developed based on the United Nations Development Program's Human Development Index that is used at a national level and local indices such as the Community Vitality Index and the Neighborhood Quality of Life Index. Figure 7 is the framework for the CAI. The variables are evaluated at a Census tract level for the 13-county region and are compared primarily by super districts (Boston 2007).

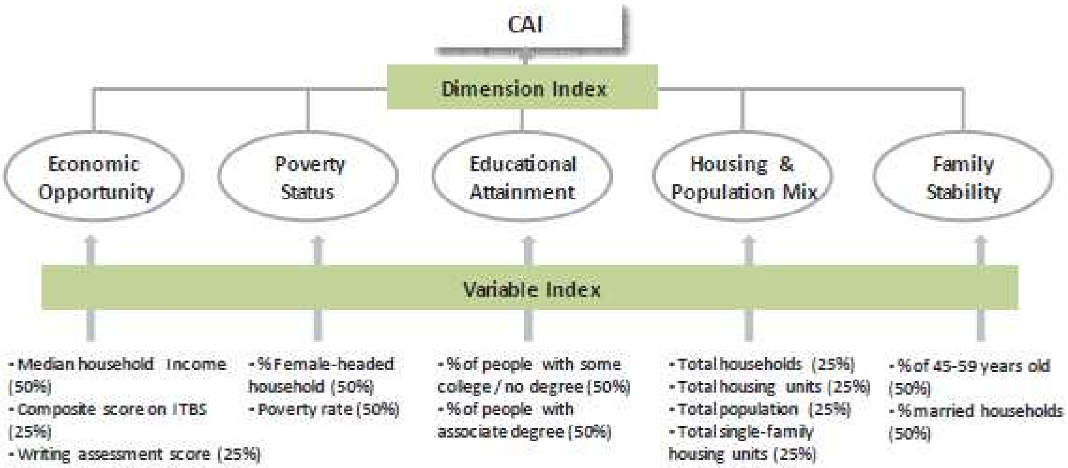

Figure 7 Atlanta Regional Commission Community Attribute Index Framework (Boston 2007)

Although the CAI incorporates various indices of need and/or disadvantage, it neglects race, a vital component in the environmental justice executive order and in all subsequent regulations. Even the consultants' report states, "The important point is not that race and poverty should be abandoned as criteria, but they should be supplemented with other metrics… (Boston 2007)" Still race is not incorporated into the new Community Attribute Index. Comparing the CAI for areas overrepresented by target populations suggests that these areas will be included. However, this does not negate the fact that race and ethnicity are not explicitly accounted for in the CAI, as per the federal guidance. The guidance expressly states that income and race are not intrinsically linked and the CAI assumes the fact that determining the disadvantaged areas in terms of education, poverty, and family stability will account for racial and ethnic target populations. Previous target populations may also be neglected using the CAI. Populations such as Limited English Proficiency and households below the median housing value for the region may still be detected through the CAI, but there are some populations that will be completely ignored such as the disabled. The elderly and zero-car households may be neglected to a lesser degree.

Despite the development of this system, a less refined index was eventually used to assess environmental justice for the Plan 2040 process. The ARC developed the

Equitable Target Area Analysis in 2011. This index uses five demographic parameters to identify disadvantaged areas: age, education, median housing value, poverty and race. Similar to past assessments, areas with target populations over the regional average become the assessment areas (ARC 2011). For each of the parameters, these locations are determined and scored. The resulting scores are then combined to determine the total index for Census tracts across the region (Figure 8).

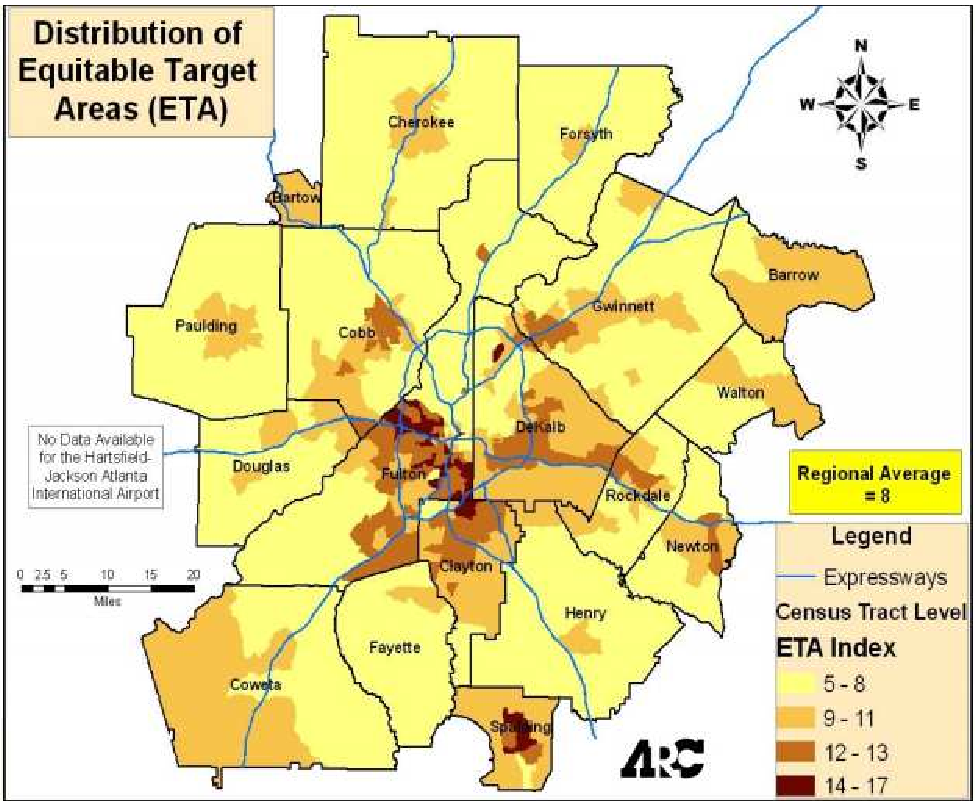

Figure 8 Atlanta Regional Commission environmental justice areas based on Equitable Target Area index (ARC 2011)

Determining the Impacts

The ARC created a multimodal accessibility profile for the region in 2010. This was part of Plan 2040 (ARC 2011) and was used to project increases in accessibility over the next thirty years. This profile (Figure 9) also highlights the ETA communities identified through the process described previously.

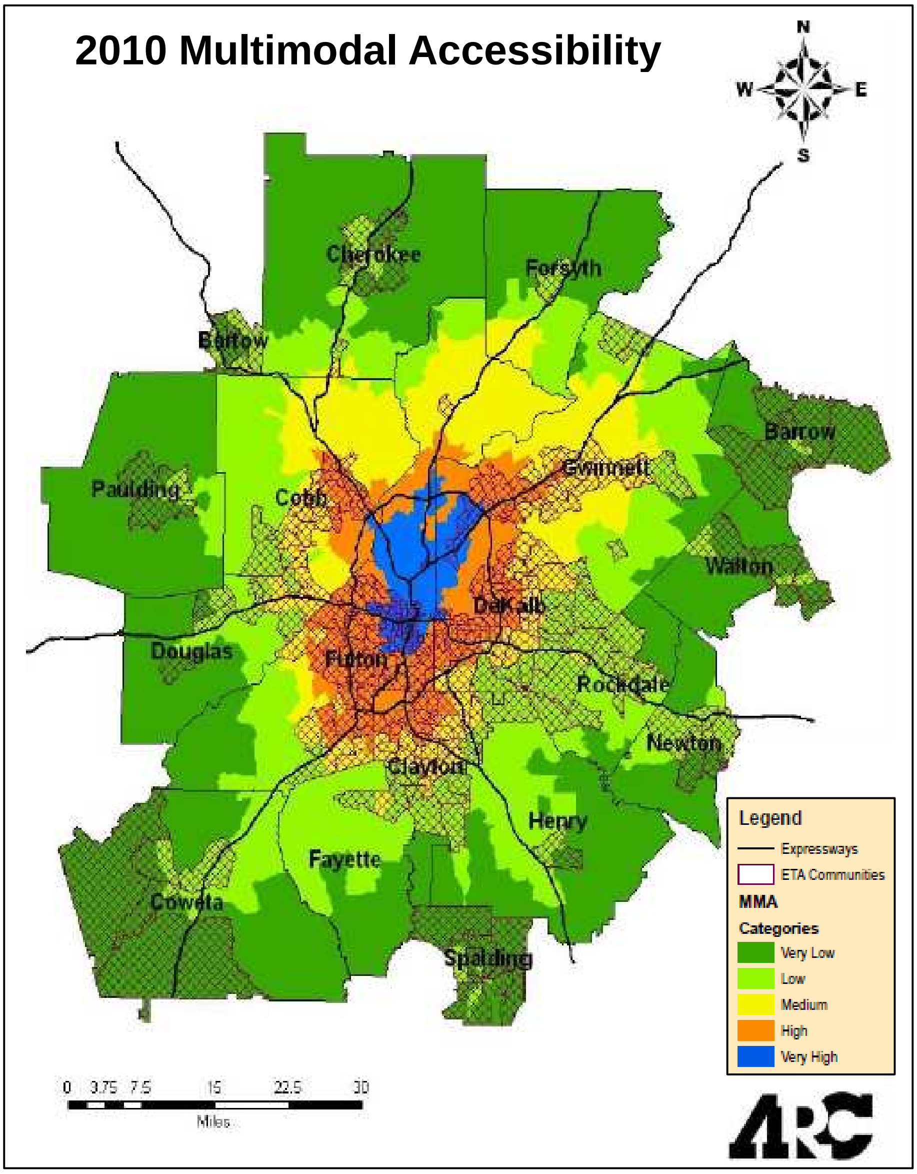

Figure 9 Atlanta Regional Commission Multimodal Accessibility Profile (ARC 2011)

The ARC multimodal accessibility profile considers the three primary modes of travel available within the region: pedestrian (walking), transit and automobile. Accessibility was derived using a general estimate of travel times for the region based on each mode. High multimodal accessibility was within a 15 minute walk, a 30 minute drive, and a 45 minute transit trip (ARC 2011). As Figure 9 shows, the highest levels of accessibility are within the perimeter expressway, along highways and transit lines. Reviewing the profile, the lack of transit throughout the region is apparent. The highest level of accessibility is visible along MARTA rail lines. As a result of the limited transit network (rail in only Fulton and Dekalb counties), other areas of high accessibility likely depend on automobile use.

This profile neglects a key component for measuring accessibility; opportunities. Short travel time alone does not constitute accessibility if there is no desired destination within that travel time buffer. ARC has also completed accessibility profiles for employment; however, critical features for social inclusion have not been evaluated expressly.

CHAPTER 3

ENVIRONMENTAL JUSTICE ASSESSMENT FOR ACCESSIBILITY TO CRITICAL FACILITIES IN THE ATLANTA METROPOLITAN REGION

Problem Statement

Local agencies must comply with environmental justice regulation and as such, it is important that they possess practical tools to identify target populations and assess impacts of projects, programs, and policies on these populations. There is a plethora of methods that can be used to attain both ends and they vary among agencies. The focus of environmental justice assessments is often at a project level.

The micro-level analysis of environmental justice inhibits the evaluation of impacts from policies (and projects also) on a regional level. Accessibility is a regional impact of transportation improvements that cannot be evaluated at a project level. It is becoming increasingly common practice that Metropolitan Planning Organizations assess the accessibility of their region, but few incorporate this benefit into the environmental justice evaluation. This is a benefit that has implications for participation in society and the lack of accessibility inevitably becomes a burden. Is there an equitable level of access across the Atlanta Metropolitan region and for all segments of the Atlanta regional population? I postulate that there is not for the reasons given below.

Studies have been conducted in cities such as Detroit, Baltimore, Boston, and San Francisco that show, as one might expect given the Monocentric City model, that the urban city core provides the most accessibility; however, this accessibility is largely based on the availability of a car. Grengs (2010) suggests that, “limited automobile ownership contributes to high rates of unemployment in the inner-city.” This is a result of auto-centered policy. Grengs defines modal mismatch using the words of Blumenberg –

“a drastic divergence in the relative advantage between those who have access to automobiles and those who do not.”

The concept that poor inner city residents are disadvantaged by the lack of personal automobiles and not the growing distance to suburban jobs is examined in depth in Grengs (2010) study of Detroit. The study finds that the central city has the highest accessibility for automobiles and transit. Yet transit accessibility at best is lower than the lowest accessibility by automobile. In addition, there is considerable variation between neighborhoods. Atlanta is not as transit-poor as Detroit, yet the results of this study may still apply. Given that the issue is one of modal options disparity and not physical distance, sprawling metropolitans create a situation where low-income and other transit captive populations then become disadvantaged by the reduced access outside of the transit accessible core. Given Atlanta’s transit system with limited rail service and reduced bus routes and the region’s reliance on the automobile, this presents an issue for the metropolitan area. This problem is exacerbated when access to critical features via transit in included in the assessment.

This work conducts an environmental justice assessment for the Atlanta metropolitan region evaluating accessibility to critical features available via transit. A method for determining target populations for the region is developed and used to assess the opportunities available to these populations.

Approach

The approach used to assess the accessibility for environmental justice populations in the Atlanta metropolitan region used the framework for the quantitative analysis of environmental justice outcomes (Figure 10). The population was defined as the Black, American Indian, Asian, Native Hawaiian and Pacific Islander, and Hispanic. These populations were used to develop spatial statistical clusters for the 29-county metropolitan region. Accessibility was measured using cumulative opportunity to determine the impacts and disproportionality was analyzed using a buffer comparison index modified for opportunities rather than population.

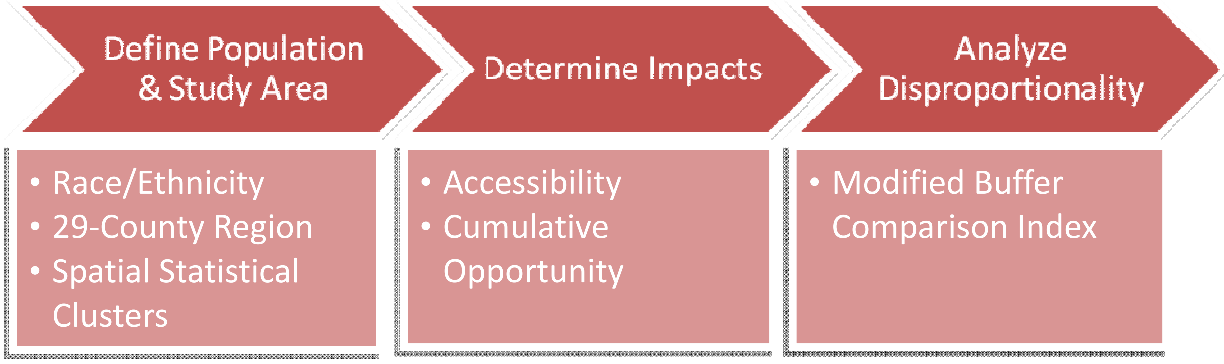

Figure 10 Framework for quantitative analysis of environmental justice for Atlanta regional accessibility

Defining Population and Study Area – Spatial Statistical Clustering

Victoria (2006) uses the spatial statistical tool, local Moran's I, to develop clusters of target populations for environmental justice assessments. The rationale behind this method is to address the pitfalls of thresholds that are sensitive to the reference population and the geographic scale of analysis. This was accomplished by overlaying clusters for the minority population and the low-income population. A scoring matrix was developed to determine target populations across a spectrum of high to low concentration for both variables. A map of target populations using the scoring system was converted to a raster map and analyzed at a pixel level to allow very small populations to be evaluated. The concept of delineating target populations from non-target populations on a basis of clusters was adapted from the Victoria study. This method grapples with the very concern that ARC voiced about its previously defined environmental justice areas. By basing the determination of environmental justice areas solely on regional averages some areas that are not "disadvantaged" may be included and others that are may not. Although the Victoria study was conducted at a project level, global spatial statistic tools, such as Getis-Ord G*-i, can prove a useful tool for regional environmental justice assessments.

By using Getis-Ord G*-i, Census tracts with a relatively high number of target population households are grouped in a cluster with adjacent tracts that also have a relatively high number of target population households. Based on Tobler's first theory of geography that "everything is related to everything else, but near things are more related than distant things (Tobler 1970)," Getis-Ord G*-i identifies neighboring geographic units with similar characteristics and determines areas of high concentration. If one imagines each geographic unit as a cell in a matrix with a weight W, if W_i is high and the weight of surrounding cells j, k, and l, are also high in comparison to all other cells, this will be a hot-spot. The same is true of the converse. If W_i is low and the weight of surrounding cells j, k, and l, are also low in comparison to all other cells, this will be a cold-spot. The sum of the local weights of cell i and its neighbors is compared proportionally to the sum of the weights of all the cells. If this local sum is substantially different than the local sum that would be expected (given the weights of all cells) and the difference is large enough to negate random chance, a statistically significant Z-score will be assigned to cell i. If the same is true for cells j, k, and l, a cluster of four cells results. The Z-score may be positive, suggesting a hot-spot, or negative, suggesting a cold-spot. This Z-score represents the number of standard deviations from the mean and can be used to reject the null hypothesis. Getis-Ord G*-i is a spatial statistical tool that assumes the null hypothesis that there is no spatial clustering of values, in this example, cell weights. In addition to a large Z-score, if the p-value is very small, the null hypothesis can also be rejected. The p-value represents the probability that the clustering pattern is the result of a random process. Figure 11 depicts the statistical spread of Z-scores and p-values for Getis-Ord G*-i.

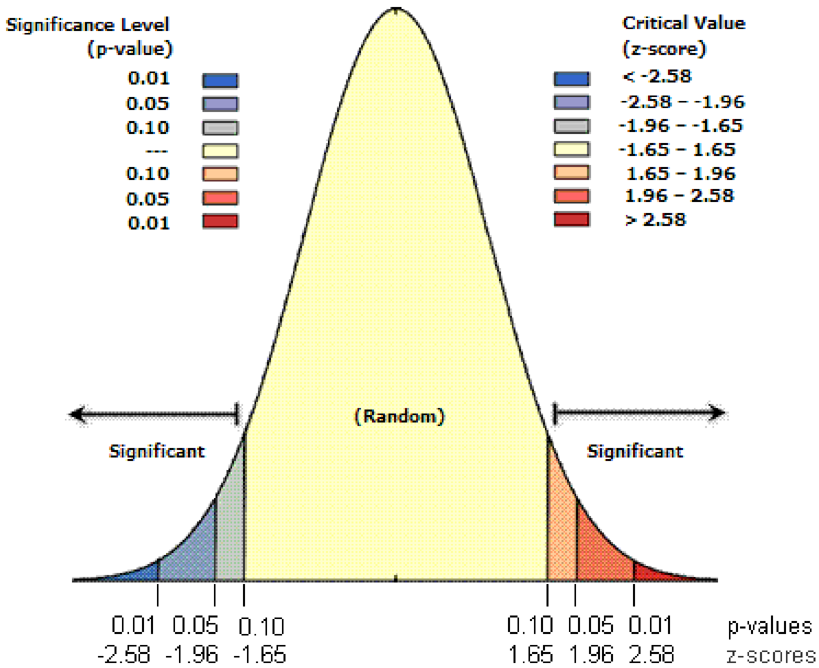

Figure 11 Significant values for Getis-Ord G*-i spatial statistical tool (ESRI 2012)

The cluster approach threatens to overlook a federal requirement that target populations, no matter how small, are accounted for in environmental justice assessments. A sole Census tract with 30% more of a target population than the region will not be identified if it is surrounded by tracts that have 30% less than the regional average. The cluster approach creates a measure of similarity and proximity. Although some tracts may be neglected, this process allows clear identification of where there are high concentrations of target populations and provides a more regional view of the demographic distributions. Each tract is not individually examined; this is useful for impacts that are more regional and wide-sweeping, like accessibility.

Clusters also function well in the Atlanta region given the historic and perpetual segregation across racial and ethnic lines. Systematic policy practices concentrated African-American and black population to the south of the city while immigration patterns concentrated Asian and Latino populations in Gwinnett County (Hayes 2006, Bullard 2000). Despite the social repercussions, the segregation of ethnicities provides an interesting climate in which to apply a cluster analysis. Tobler's first theory also suggests that low-income households will tend to cluster. This concentrated poverty however, is the target of many social policies to distribute poverty in hopes of reducing its perpetuity.

The cluster approach also provides a relative threshold. While it is still a function of the total reference population, the relative threshold is a statistically derived value rather than arbitrarily chosen or based on the average regional population statistics. The clusters also provide the ability to assess a large geographic area for impacts that are regional in nature.

Determine Impacts – Accessibility Framework

From the literature, a framework for understanding and selecting accessibility measures was distilled (Figure 12).

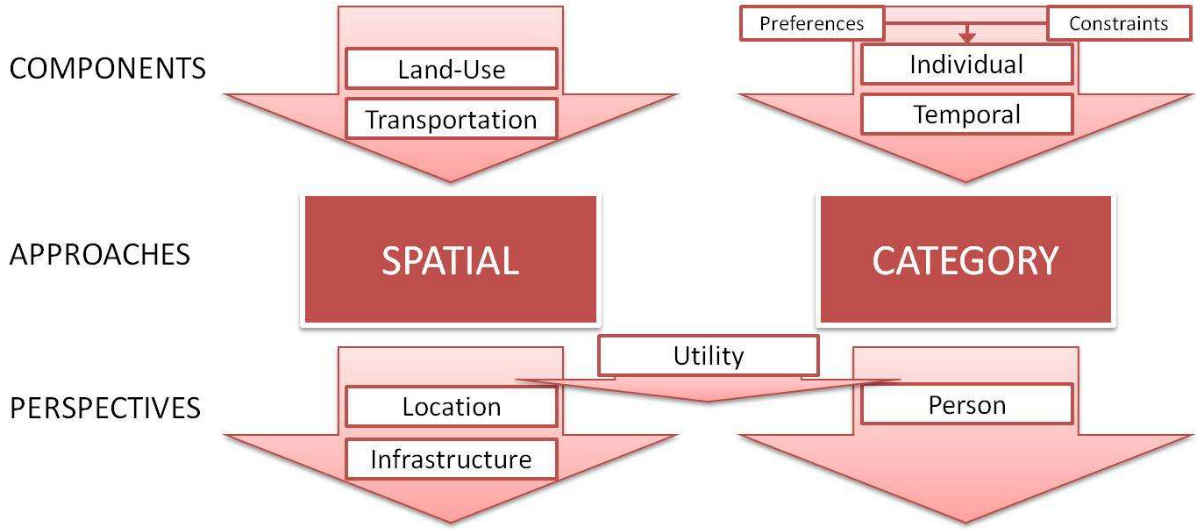

Figure 12 Framework for categorizing and selecting accessibility measures

The arrows at the top of the framework represent the input components. Land-use and transportation components are used in a spatial approach and individual and temporal components are used in a category approach. Note that preferences and constraints play into the individual and temporal components. Based on the approach taken, the accessibility measure will have a location or infrastructure perspective (spatial) or a person perspective (category). A utility perspective can result from either approach and a combination of approaches can result in various perspectives. For the following analysis, individual and temporal inputs are not available. For a regional assessment of accessibility using individual and temporal components, it is possible to use activity spaces derived from travel behavior. Activity space differs among different segments of the population. To develop activity spaces, travel survey data is required. Such data exists for the Atlanta metropolitan region via the 2000 SMARTAQ travel survey, however, it is outdated. A new travel survey was conducted in 2011, the results of which were published in March of 2012. Further research may find it useful to incorporate this updated travel survey data to develop activity spaces for various segments of the population and use these spaces, rather than clusters, to include a person-based perspective in the assessment of accessibility in the region. Incorporating travel demand analysis results could provide another avenue to incorporate the individual component. However, given the land-use and transportation inputs available for the assessment at hand, a conventional spatial approach was taken.

Conventional methods are useful for measuring aggregate accessibility among various social groups within an area-based framework. They can be useful in examining changes in accessibility across different locations and despite their limitations in disaggregate analysis, individual demographics such as income and age can be incorporated into the measures (Kwan and Weber 2003). Although cumulative opportunity is a conventional and unsophisticated method to evaluate accessibility, it serves several purposes in this analysis. The lack of personal travel data limits the ability for person-based or utility-based accessibility measures. As mentioned previously, the most recent travel survey for the Atlanta region was performed ten years ago. This information would fail to produce accurate results. Use of the recently finished survey data could allow more sophisticated analysis of regional accessibility. Unfortunately, that data was not available at the time of this analysis. Use of clusters, however, provides an estimated view of where the target populations reside and it can therefore provide an estimate of their activity space. Because most of these clusters are very large and span many Census tracts, estimating a distance from the periphery or the centroid would not provide substantial accuracy to use a gravity model. In addition, analyzing the distance along the transportation network to destinations would carry little weight with such a large area of possible origins.

Atlanta has an accessible road network so in assessing accessibility, focus was given to the transit system. Also since accessibility is heavily based on the availability of transportation options, evaluating transit accessibility provides insight into various modes of transportation that may be available. As mentioned previously in the Grengs (2010) study, distance bares less importance in disparities of accessibility than modal options, which also supports an evaluation of transit accessibility. In addition, transit can be viewed as a "public good" and as a means of providing the liberty of transportation and accessibility to all.

Methodology

Data Acquisition

Data was acquired from the American Community Survey Data (2006-2010 five-year estimates) for the greater Atlanta metropolitan area. Demographic data for the 29-county region was downloaded. This information included, total population and populations for white, black, American Indian, Asian, Native Hawaiian and Pacific Islander, other races, two or more races, and Hispanic. The total land area of the tract as well as the total number of households, average household size, and median income for the tract were all obtained. Based on this information, the percentage of each ethnicity and race was determined. The data was formatted to produce a table that could be imported into ARCGIS.

Census block, block group and tract shapefiles were downloaded from the TIGER database. A number of shapefiles were obtained from ARC. These included: county boundaries, street networks and expressways, Cobb County Transit (CCT) lines, Gwinnett County Transit (GCT) lines, GRTA lines, MARTA lines and stations (bus and rail) and parks. These files were projected to NAD83 StatePlane Georgia West in ArcGIS. A table of community facilities was also downloaded from ARC. The table was then geocoded to provide spatial references to these facilities. In the geocoding process, 8261 facilities were matched, 73 (1%) were tied and 57 (1%) were unmatched. This was deemed acceptable and the matched facilities are those considered in this analysis. The facilities were differentiated between those necessary for social inclusion (such as schools) and emergency or other (such as firehouses). Table 9 shows the facilities included in this analysis.

Table 9: Opportunities for social inclusion obtained from Atlanta Regional Commission's database of community facilities

<table>
<tr><td rowspan="6">K-12 Educational Opportunities</td><td>Primary school</td></tr>
<tr><td>Elementary school</td></tr>
<tr><td>Middle school</td></tr>
<tr><td>High school</td></tr>
<tr><td>Private school</td></tr>
<tr><td>Other school</td></tr>
<tr><td>Technical Educational Opportunities</td><td>Public vocational</td></tr>
<tr><td rowspan="6">Higher Learning Opportunities</td><td>Two-year private college</td></tr>
<tr><td>Two-year public college</td></tr>
<tr><td>Four-year private college</td></tr>
<tr><td>Four-year public college</td></tr>
<tr><td>Private university</td></tr>
<tr><td>Public university</td></tr>
<tr><td>Other Learning Opportunities</td><td>Library</td></tr>
</table>

The transit shapefiles were also differentiated. Express service buses for CCT and GCT were separated from local service. Local service lines for CCT and GCT were merged with MARTA bus lines and rail station stops. This provided a file with all local transit service. Because work trips were not a focus of this analysis, express commuter bus was not evaluated. The local service was buffered by a quarter of a mile to suggest an area within walking access to local bus and rail service. The 24 MARTA stations with parking were also buffered at 1, 2, and 5 miles to identify areas within reasonable driving distance to MARTA rail. There are, however some limitations to the transit data. Obvious issues arise when assuming that simply residing within the transit buffer provides access. Physical limitations such as expressways, fences, or disabilities may encumber access to transit facilities. Travel time to destinations along transit routes may also be lengthy and may require multiple transfers, reducing the utility of transit to choice destinations. The desired destinations must also be within walking distance of transit lines (contained within the buffer) to provide utility for transit trips. Service limitations (long headways, abbreviated weekend hours) also play into the accessibility of locations via transit, however, it is not captured in this buffer analysis. In addition, the transit shapefiles, while the most recent for the region, are outdated for the current transit routes. The shapefiles date to 2006, since that time, MARTA and CCT have made route adjustments and Clayton County Transit (CTRAN) was eliminated. An ARC meeting held in February 2012 addressed the need for a regional transit data warehouse and open source data (ARC Website). It is promising for future transit studies to have the most current GIS data and possibly information about service and temporal constraints. One final note on transit, those who are transit dependent will be willing to walk a greater distance to reach transit if necessary and be more likely to endure the travel time costs.

Data Analysis

The shapefiles and demographic information were loaded into ARCGIS. Demographic data was joined with the spatial information on the Census tract level. Using Getis-Ord G*-i, clusters were created of Census tracts for each of the races and ethnicities. Clusters of high concentrations of each racial and ethnic population were created using Getis-Ord G*-i spatial statistical analysis for inverse distance (Figure**).

A field was added to the attribute table for each of these clusters to score each tract from -3 (very cold and around other very cold tracts) to 3 (very hot and around other very hot tracts). This was done by implementing the following code in the new field:

```
if [GiPValue] <.01 then
if [GiZScore] < -2.58 then
  value = -3
elseif [GiZScore]>-2.58 AND [GiZScore]<-1.96 then
  value = -2
elseif [GiZScore]>-1.96 AND [GiZScore]<-1.65 then
  value = -1
elseif [GiZScore]>-1.65 AND [GiZScore]<1.65 then
  value = 0
elseif [GiZScore]>1.65 AND [GiZScore]<1.96 then
  value = 1
elseif [GiZScore]>1.96 AND [GiZScore]<2.58 then
  value = 2
elseif [GiZScore]>2.58 then
  value = 3
end if
else value = 0
end if
```

This also accounts for the statistical significance (p-value). The new scores allowed the tracts with similar scores to be dissolve creating polygons for clusters that scored a 3 (very hot). For each target population, the clusters were dissolved in this way.

All of the dissolved cluster shapefiles were merged and the polygons with scores of three were selected. A separate shapefile was created with these polygons. These polygons represent the areas of high concentration of target populations. These polygons were then dissolved to produce several polygons that encompass the areas with high concentrations of all target populations.

The merged cluster polygons were used to clip the original Census tract file and resulted in a shapefile highlighting the areas of high concentration of target populations and all other demographic information. Using both the merge and clipped layers, it is possible to implement cumulative opportunity to determine the accessibility for target populations.

Transit access can be determined by clipping the local transit buffer within the target population cluster and assessing the new area. A similar process was used to determine the park area within the cluster. Using the select by location tool, the number of schools, libraries, and institutions of higher education were counted within the cluster. The same process was done to identify the area of parks and community facilities within the transit buffer.

Disproportionality was determined using a variation of BCI. Because the cluster method identifies areas of overrepresentation of the target populations, the BCI would not provide the disproportionality that is desired for this analysis. The objective is to determine if the opportunities in the clusters are disproportionate to those outside the cluster. This proportion is then normalized to the population. The following equation was used as a modified BCI:

$$Modified\ BCI = \frac{\text{Opportunities in cluster/Opportunities in reference area}}{\text{Total population in cluster/Total population in reference area}}$$

If the modified BCI is above a 1, the opportunities in the cluster outweigh those outside the cluster. If the modified BCI is less than 1, the opportunities outside of the cluster outweigh those in the cluster.

Results

From the process outlined, the opportunities within the cluster can be determined. Figure 13 through Figure 18 show the spatial distribution of the identified facilities across the Atlanta metropolitan region and their relation to the target population cluster.

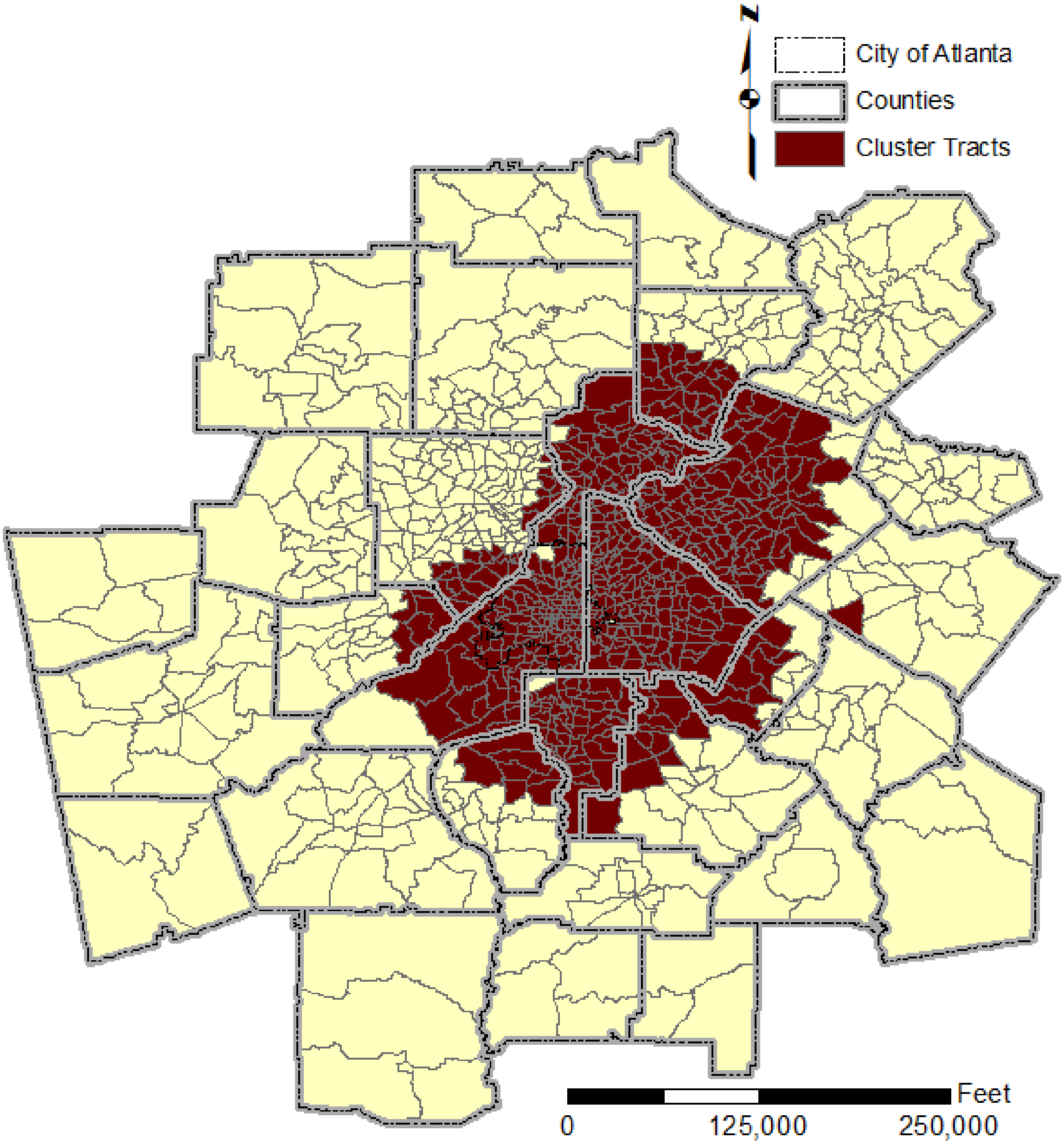

Figure 13 Result of cluster analysis for target populations. Shows areas of high concentration of target populations.

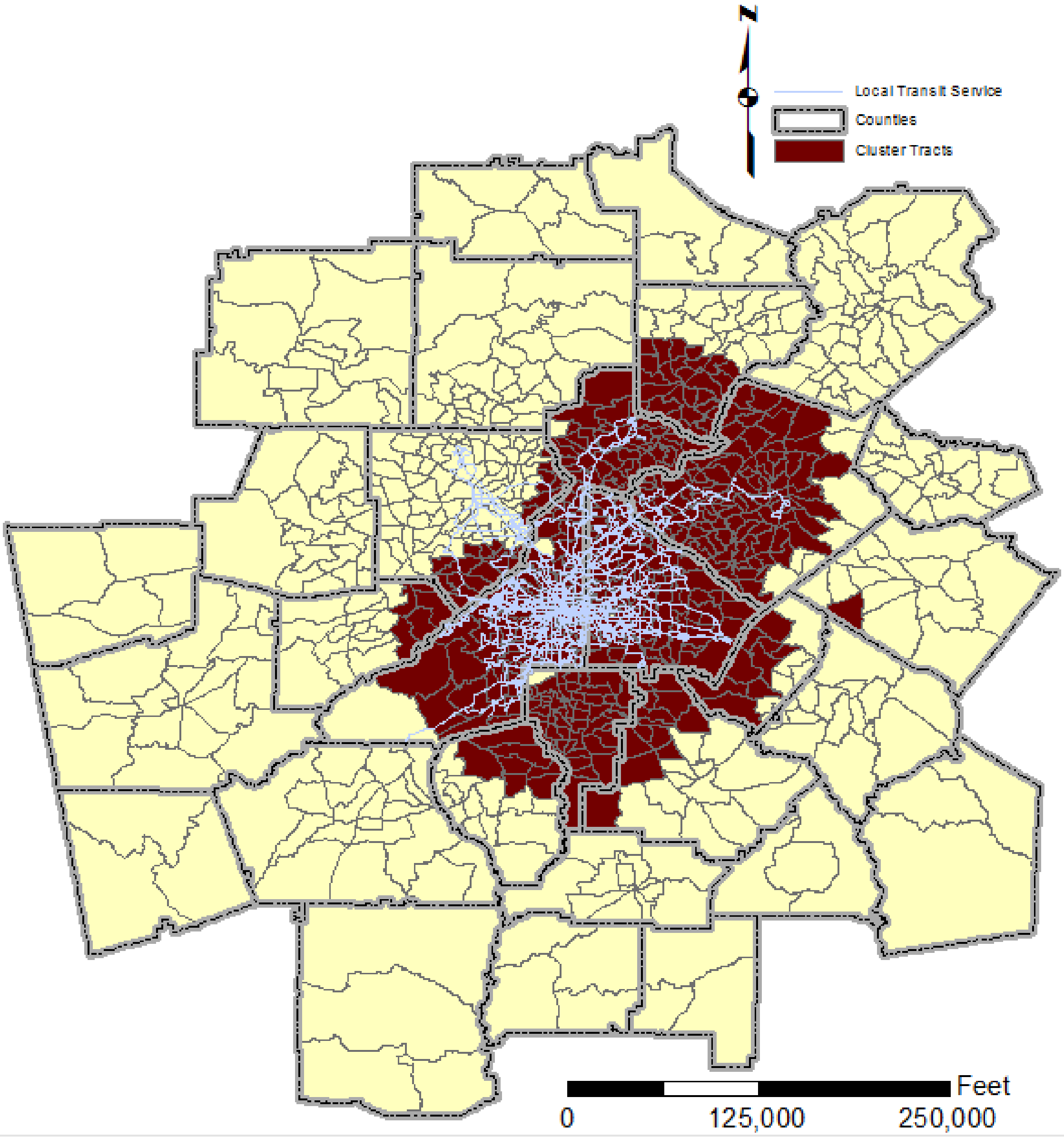

Figure 14 Local transit service in relation to target population cluster

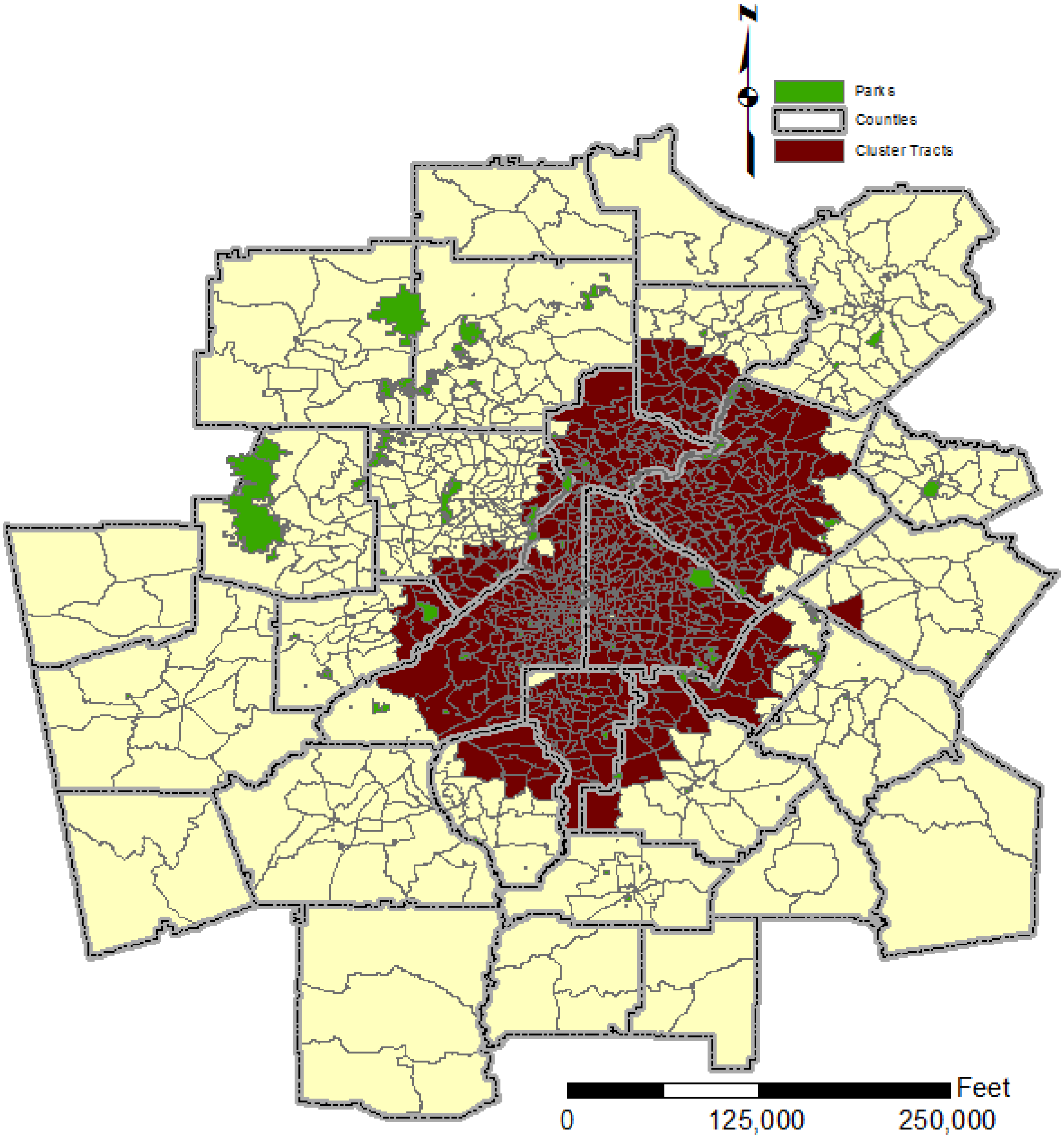

Figure 15 Park space in relation to target population cluster

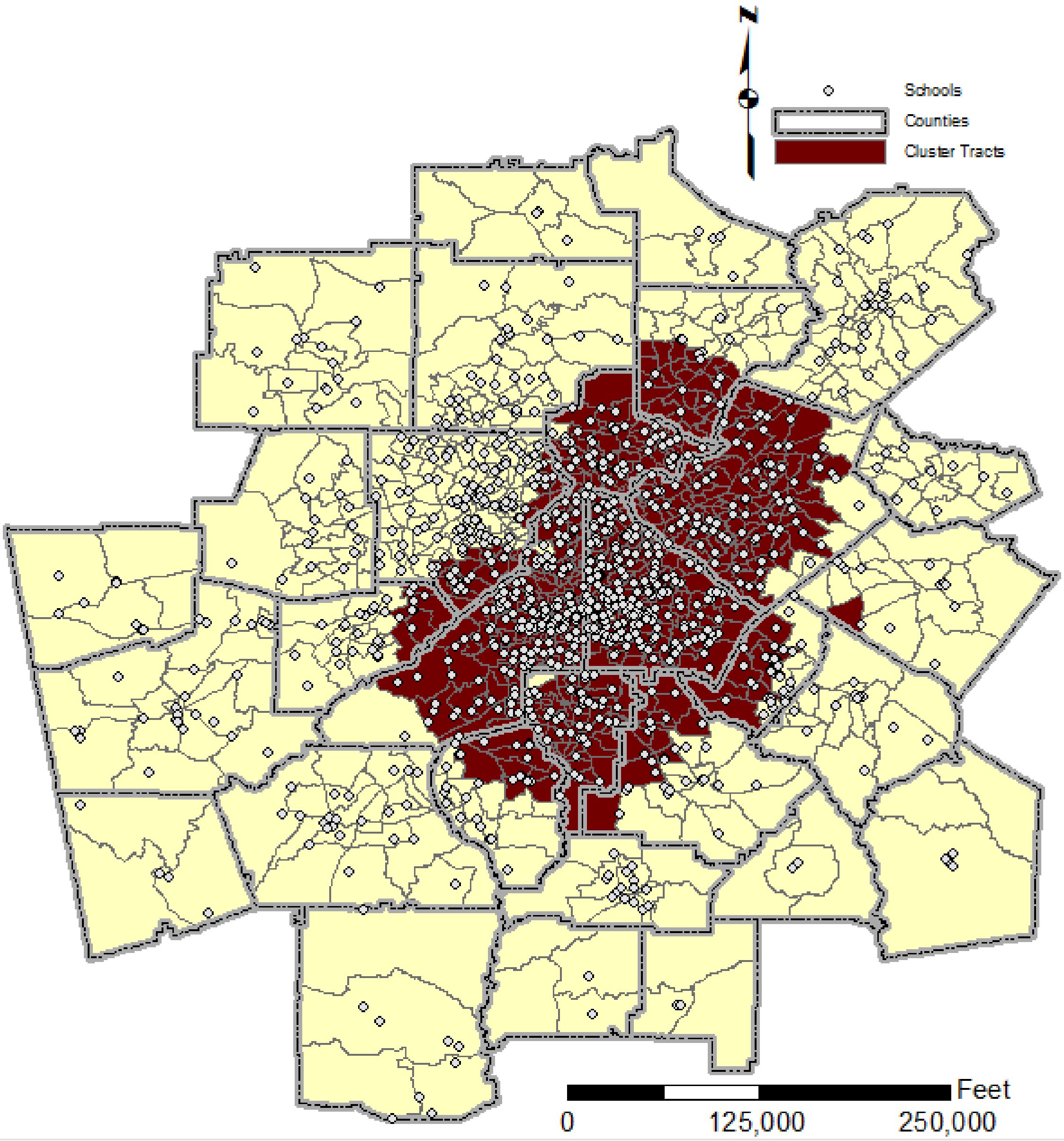

Figure 16 K-12 education facilities in relation to target population cluster

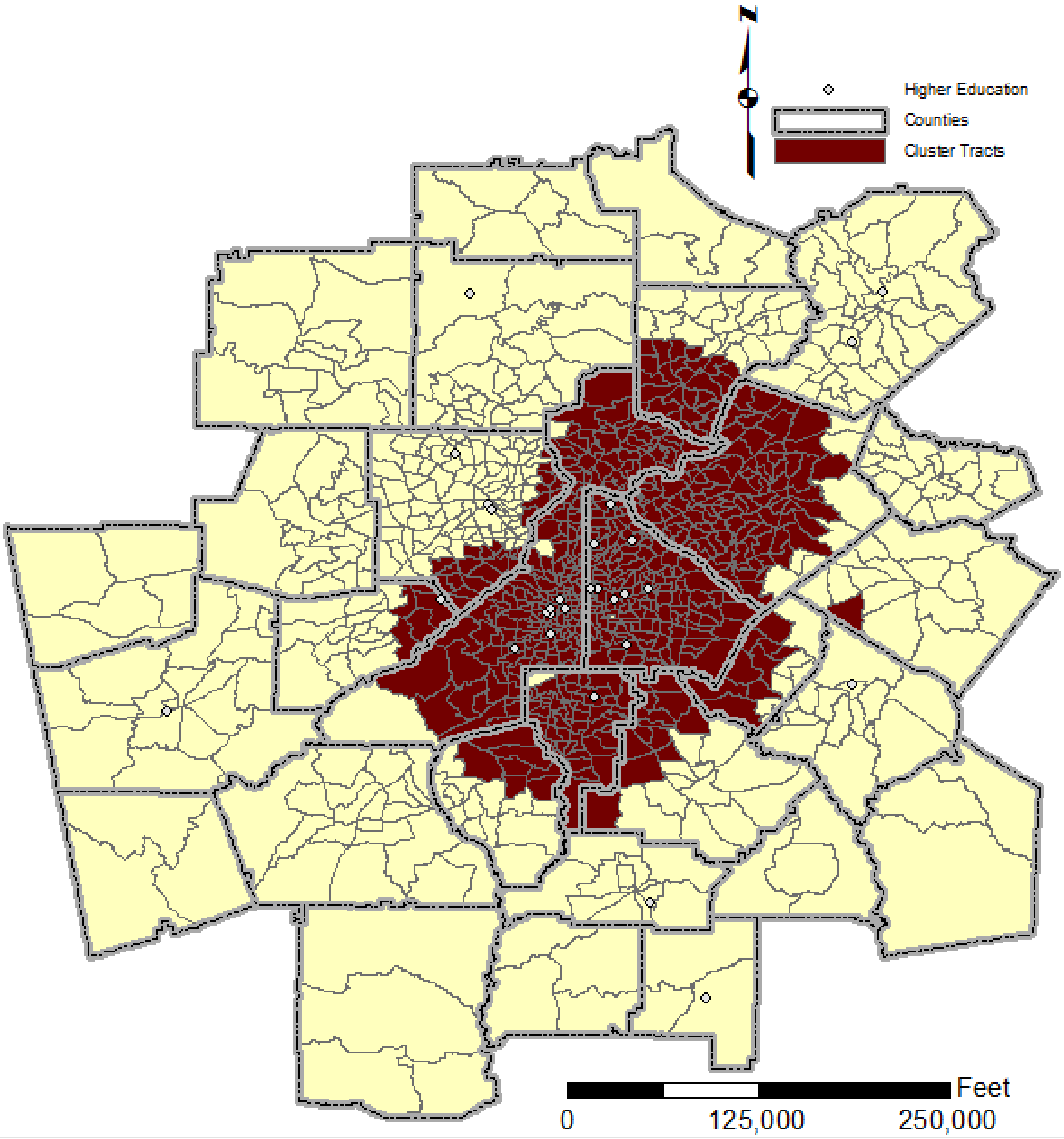

Figure 17 Colleges and Universities in relation to target population cluster

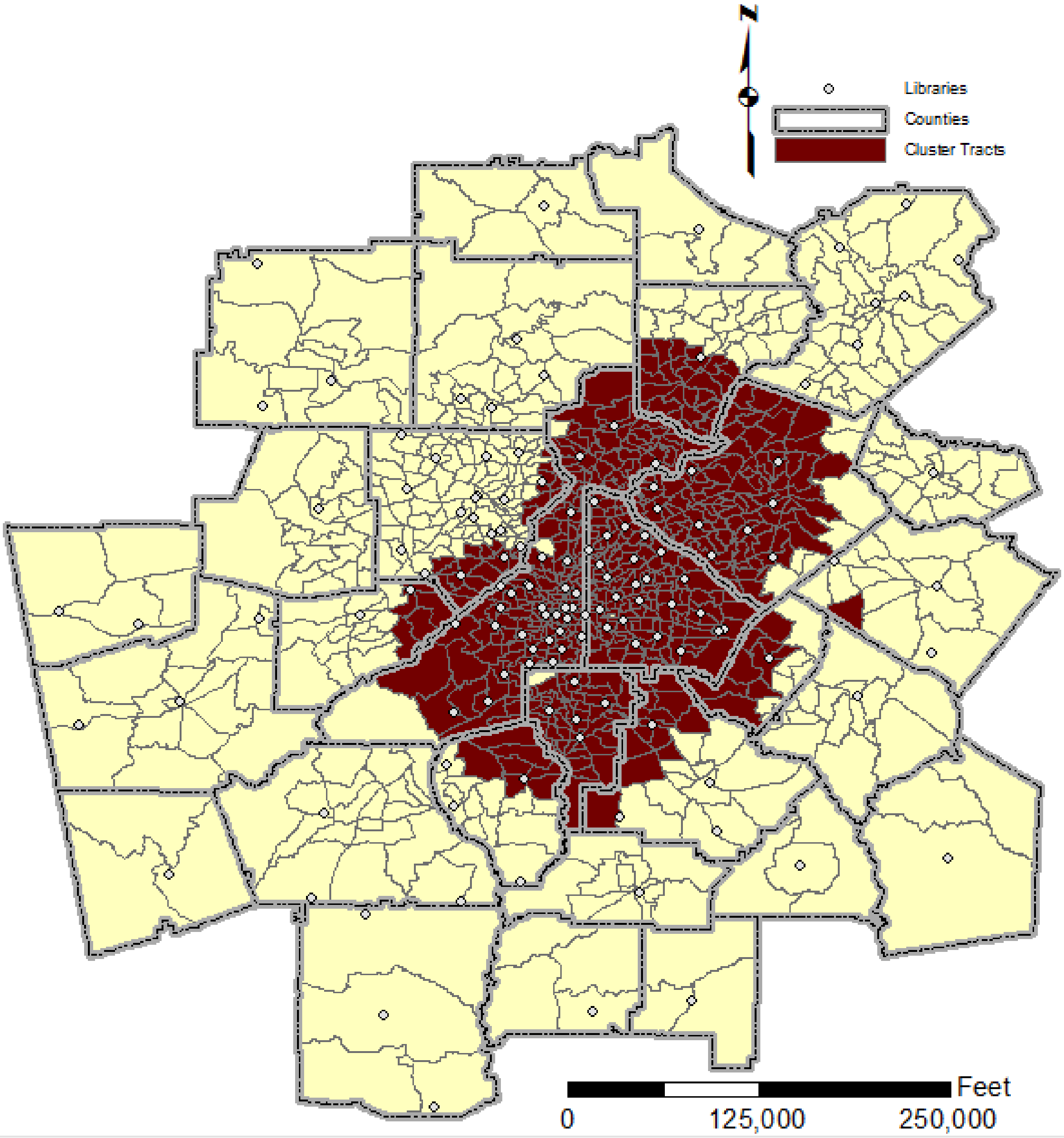

Figure 18 Libraries in relation to target population cluster

Quantitative results and analysis are found in

Table 10.

Table 10: Quantitative Results for Accessibility of Key Facilities

Facility	Region/ Reference	Non-Cluster	% of Total	Cluster	% of Total	BCI
Area (sq. mi.)	8910.33	7223.28	81.07%	1687.05	18.93%	--
Population	5,300,114	2,324,748	43.86%	2,975,366	56.14%	--
Area of Transit Buffer (sq. mi.)	377.70	44.67	11.83%	333.02	88.17%	1.57
Libraries	140	59	42.14%	81	57.86%	1.03
Higher Learning	29	10	34.48%	19	65.52%	1.17
Schools	1056	415	39.30%	641	60.70%	1.08
Technical Schools	13	8	61.54%	5	38.46%	0.69
Area of Parks (sq. mi.)	179.98	131.51	73.07%	48.47	26.93%	0.48

Discussion

The results of the data analysis provide a glimpse into the spatial distribution of target populations and key facilities across the Atlanta Metropolitan Region. Through the use of clusters, cumulative opportunity and rational comparison methods, and environmental justice analysis for access to key facilities was conducted.

The results of the analysis show that while the target population cluster comprises 19 percent of the land area of the region, it is home to over half of the population for the region. This is an understandable conclusion. The cluster is contained primarily in Fulton, DeKalb, Gwinnett and Clayton Counties, four of the five most populous counties in the region (US Census). As such, it also translates that many of the social facilities such as schools and libraries are located within the cluster. For many of the facilities the BCI was in excess of 1. This reflects the presence of more facilities within the cluster than outside the cluster.

An interesting finding is that almost the entire transit buffer zone is contained within the cluster. It is logical since Fulton and DeKalb Counties are the sole counties with MARTA, the largest transit provider in the region, that the cluster's heavy presence in Fulton and DeKalb counties would result in a heightened transit area. In addition, understanding that over half of the region's population resides on less than 20 percent of the land, it follows that the population density in the cluster is relatively high. This is also a logical case for the transit area.

The park area however is quite the converse. With a BCI of under 0.5, the overwhelming majority of park space is outside the clustered area. The varied land use and terrain across the region could play a role in the siting of park space, however, the disparity between the cluster and the remainder of the region is cause for concern.

The target population cluster generally spans across urbanized areas and suburbs. As has been shown by Grengs and others, urban areas have the highest level of accessibility, with availability of an automobile. Yet, since the great majority of local transit lines are within the cluster, this area is also best served by transit across the region. Table 11 shows the opportunities that are also within the transit buffer area. All the higher education and technical facilities in the clusters are within the transit buffer and a majority of the libraries are also. Less than half of the schools within the cluster are within a quarter mile of local transit. These schools are generally on the periphery of the cluster where there are fewer local bus routes. In these areas there are also fewer schools and larger Census tracts signifying that there are also less people residing in these areas. This could translate to less justifiable demand for transit. Despite less transit access to schools, it is likely these facilities are served by local school buses as well. Again, the most substantial figure is the area of parks within the transit buffer. Less than 20 percent of the park area within the clusters is in the transit buffer and barely 5 percent of the total park area is in the transit buffer.

Table 11: Quantitative Results for Facilities in Transit Buffer

Facility	Region/ Reference	Transit Access	% of Total	% Cluster
Area (sq. mi.)	8910.33	377.69	4.24%	22.39%
Libraries	140	60	42.86%	74.07%
Higher Learning	29	19	65.52%	100.00%
Schools	1056	309	29.26%	48.21%
Technical Schools	13	5	38.46%	100.00%
Area of Parks (sq. mi.)	179.98	8.30	4.61%	17.12%

Even given these findings, what is still to be seen is the true distance and/or travel time that transit riders experience in reaching destinations across the region.

Conclusion

Determining the distributive effects (burdens and benefits) of transportation improvements can be accomplished by defining the population, delineating a study area, determining impacts and then analyzing the disproportionality of these impacts. Although this process is best suited for project level analyses, it can be applied generally to evaluate policy responses and regional effects. One such regional effect is accessibility. Accessibility to destinations is a benefit of the transportation system and when these destinations are also opportunities for social inclusion, accessibility becomes a liberty that should be extended to all segments of the population. Ensuring accessibility to critical facilities is an environmental justice issue.

To evaluate the accessibility to various critical facilities for environmental justice target populations in the Atlanta metropolitan region, ARCGIS spatial statistical tools and proximity measures were used. The results showed that there are high concentrations of target populations in highly populated areas of the region and as such, they have access to many of the public facilities including schools, libraries and transit. Park area, however, is a public facility that is not often found within the areas with high concentrations of target populations or in proximity to transit.

Disparate accessibility is significant because it can be viewed as an inequitable cumulative outcome of transportation investments and therefore becomes an environmental justice concern. Accessibility evaluations are necessary to assess the ability of various populations across a region to access features and facilities vital for social inclusion. This work conducted an analysis of racial and ethnic minority access to educational and recreational facilities. As a result, a more comprehensive idea of accessibility for environmental justice populations was obtained. This is especially important given the current method that the Atlanta metropolitan region uses to analyze accessibility, particularly in regards to environmental justice.

Translating this work into a more general context, the tools used can be applied for other analyses. The variety of methods used to identify environmental justice target populations across MPOs suggests that defining a population is a problem yet to be solved. By translating a method that has been used to assess project areas to a regional scope, complications with disproportionality thresholds are minimized. This method also identifies areas with high concentrations of target populations, pinpointing areas of overrepresentation of target populations and estimating the distribution of these populations across the region, which can provide more practical and useful information than a tract-by-tract demographic profile.

Using this approach, additional populations can be included in the analysis. Access for low-income households and other target populations can be determined. Access to additional facilities can also be assessed. Some private facilities that are not publicly subsidized are still critical for participation in society. Access to locations such as grocery stores and shopping destinations should be evaluated. A utility perspective can also be incorporated into this approach by performing a network analysis along the local transit lines to determine actual travel distance and time along each line to the facilities.

Assessments for accessibility of various populations can also be expanded on the basis of this approach. To better understand the access to transit for target populations, a spatial statistic assessment around stations, stops, and local transit lines using local Moran’s I can provide insight. And although the spatial approach is useful for a large regional area with a multitude of people, the use of activity spaces in lieu of clusters could incorporate a categorical approach with an individual component.

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